PROCEEDINGS OF THE SECOND WORLD SEED CONFERENCE

Responding to the challenges of a changing world: The role of new plant varieties and high quality seed in agriculture

FAO Headquarters, Rome, September 8-10, 2009

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EXECUTIVE SUMMARY

Declaration from the Second World Seed Conference

Urgent government measures and increased public and private investment in the seed sector are required for the long term if agriculture is to meet the challenge of food security in the context of population growth and climate change.

Governments are strongly encouraged to implement a predictable, reliable, user friendly and affordable regulatory environment to ensure that farmers have access to high quality seed at a fair price. In particular, FAO member countries are urged to participate in the internationally harmonized systems of the Organization for Economic Cooperation and Development (OECD), the International Union for the Protection of New Varieties of Plants (UPOV), the International Treaty on Plant and Genetic Resources for Food and Agriculture (ITPGRFA) and the International Seed Testing Association (ISTA). Participation in those systems will facilitate the availability of germplasm, new plant varieties and high quality seed for the benefit of their farmers, without which their ability to respond to the challenges ahead will be substantially impaired. The conference emphasized the important role of both the public and the private sectors to meet the challenges ahead and the benefits when the two work together. The Second World Seed Conference emphasized that agriculture needs to provide sustainable food security and economic development in the context of current and future global challenges. The Conference highlighted the critical role of new plant varieties and high quality seed in providing a dynamic and sustainable agriculture that can meet those challenges. It concluded that governments need to develop and maintain an enabling environment to encourage plant breeding and the production and distribution of high quality seed. The global seed market has grown rapidly in recent years and is currently worth around US$37 billion. Cross border seed trade was estimated to be worth around US$6.4 billion in 2007. The Second World Seed Conference was held at FAO headquarters from September 8-10 and organized in collaboration with the OECD, UPOV, ITPGRFA, ISTA, ISF.

Conference Conclusions

- Plant breeding has significantly contributed and will continue to be a major contributor to increased food security whilst reducing input costs, greenhouse gas emissions and deforestation. With that, plant breeding significantly mitigates the effects of population growth, climate change and other social and physical challenges.
- ITPGRFA is an innovative instrument that aims at providing food security through conservation, as well as facilitated access to genetic resources under its multilateral system of access and benefit-sharing. The multilateral system represents a reservoir of genetic traits, and therefore constitutes a central element for the achievement of global food security.
- Intellectual property protection is crucial for a sustainable contribution of plant breeding and seed supply. An effective system of plant variety protection is a key enabler for investment in breeding and the development of new varieties of plants. A country's membership of UPOV is an important global signal for breeders to have the confidence to introduce their new varieties in that country.
- Seed quality determination, as established by ISTA, on seed to be supplied to farmers is an important measure for achieving successful agricultural production. The establishment or maintenance of an appropriate infrastructure on the scientific as well as technical level in developed and developing countries is highly recommended.
- The development of reliable and internationally acceptable certificates, through close collaboration between all stakeholders along the supply chain for varietal certification, phytosanitary measures and laboratory testing, contributes substantially to the strong growth in international trade and development of seed markets to the benefit of farmers.

Conclusions of the Expert Forum

Session 1
The role of plant breeding in meeting the multiple challenges of a fast-changing world

- Improved varieties and high quality seeds are basic requirements for productive agriculture, which is the basis of sustainable economic development in developing economies
- Through the efforts of both the public and private sectors, plant breeding has provided an enormous contribution to global agriculture (yield, resistance to biotic stresses, tolerance to abiotic stresses, harvest security, quality traits including nutritional value, etc.)
- Plant breeding has the ability to significantly contribute in solutions to several of the challenges ahead such as food security, hunger alleviation, increasing nutritional values, and higher input costs. Plant breeding and related disciplines and technologies help in mitigating the effects of population growth, climate change and other social and physical challenges
- Intellectual property protection is crucial for a sustainable contribution of plant breeding and seed supply. There are still many tools and traits in the pipeline that will prove to be very necessary for the continued supply of high quality varieties and seeds
- Apart from genetic enhancement, other technologies, e.g. quality seed production and seed treatments, contribute substantially to improved seeds, and capacity building in all these areas is urgently needed in developing countries.

Session 2
The importance of plant genetic resources for plant breeding; access and benefit sharing

- Plant breeding and the sustainable use and conservation of genetic resources are interdependent.
- The International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) is a unique and innovative legally binding instrument providing facilitated access to genetic material for plant breeding at the international level
- The Multilateral System (MLS) of the ITPGRFA provides a consistent Access and Benefit-sharing option for plant breeding activities
- The Standard Material Transfer Agreement (SMTA) of the ITPGRFA is a contract between the provider and the recipient that is simple to use and facilitates access to germplasm
- The involvement of the private sector in the design of Access and Benefit-sharing schemes is necessary for a well functioning Access and Benefit-sharing mechanism
- Material in the MLS is a source of genetic traits and characteristics of interest
- The full success of the ITPGRFA and its MLS will depend on local, national and regional implementation, as well as on the availability of funds at the local, national and regional level.

Session 3
Plant Variety Protection

- The number of new varieties increased after the introduction of plant variety protection.
- Introduction of the UPOV system of plant variety protection was associated with increased breeding activity and with the encouragement of new types of breeders, such as private breeders, researchers and farmer-breeders. The introduction of PVP was also associated with the development of partnerships, including public-private cooperation.
- Introduction of plant variety protection was associated with the development of new, protected varieties that provided improvements for farmers, growers, industry and consumers, with overall economic benefits.
- One of the benefits of plant variety protection is to encourage the development of new, improved plant varieties that lead to improved competitiveness in foreign markets and to development of the rural economy.
- Membership of UPOV was associated with an increase in the number of varieties introduced by foreign breeders, particularly in the ornamental sector.
- The breeder’s exemption, whereby protected plant varieties can be freely used for further plant breeding, is an important feature of the UPOV system which advances progress in plant breeding.
- Access to foreign plant varieties is an important form of technology transfer that can also lead to enhanced domestic breeding programs.

Session 4
The importance of quality seed in agriculture

- The session demonstrated the importance of seed quality for crop productivity and agricultural production. It has underlined, that a lack of information on seed quality could result in crop failures and has the potential to threaten food security for whole countries
- The determination of seed quality parameters requires a broad knowledge of plant and seed physiology, taxonomy and botany and requires intensive scientific studies and research
- The application of seed quality evaluations requires a detailed knowledge regarding seed production, seed marketing, seed regulations and the seed sector
- Since 1924 the International Seed Testing Association (ISTA) has been the impartial and objective platform where leading seed technologists and researchers have come together to discuss relevant scientific progress and make the necessary definitions regarding seed quality and how to measure it
- Currently in developing countries there is not an adequate seed quality assurance infrastructure with respect to seed testing and this is required to increase crop productivity and provide enhanced food security in these countries
- The evolution of seed quality determination has not reached an end point and there are interesting developments in the pipeline that take account of the changing needs of the market. These will make tests and their applications more relevant, effective, robust, quicker and cheaper
- Significant cuts in scientific research and education has reduced the possibility for young academics to acquire the necessary seed technology skills
- In the seed technology area transparency in and scientific exchange of the latest research results remain of crucial importance for continued progress
- Uncompetitive salaries for seed analysts in developed countries make a career in seed quality control unattractive for young people.

Session 5
Facilitation of trade and market development

- Global seed market has grown rapidly in recent years and is currently estimated at about US$37bn. Europe, North America and Asia account for almost four-fifths of the global seed trade. For 2007, the international seed trade was estimated at US$ 6.4bn
- The use of international certificates for varietal certification, phytosanitary measures and laboratory testing has greatly facilitated the development of the international seed trade
- Production and marketing of certified seed of all agricultural crops is highly regulated at both the national and international level. A transparent and efficient regulatory system is crucial to ensure that farmers have access to high quality seed at a reasonable price
- The international regulatory framework consists of certification based on varietal identity and varietal purity (OECD, AOSCA), phytosanitary measures (IPPC, WTO-SPS, NPPO), plant variety protection (UPOV) and seed testing (ISTA, AOSA, etc.)
- Regional seed regulatory frameworks have been developed and harmonised to facilitate regional trade e.g. Central America, Mercosur, EAC, SADC, ECOWAS, etc. Regional standards, such as those of the EU, are closely aligned with international standards such as those of the OECD and clearly set out the registration and certification conditions for the marketing of seed
- The increasing use of harmonised international certification procedures on varietal identity and varietal purity helps to facilitate the import and export of high quality seed by assuring consumer confidence and reducing technical barriers to trade
- Good cooperation between the public and private stakeholders in developing and setting standards that are internationally acceptable has facilitated the issuing of certificates which, in turn, has contributed to the growth in trade
- Implementation of measures to prevent the introduction and spread of plant pests is critical to ensuring the development of a viable and sustainable global seed market. The International Standards for Phytosanitary Measures (ISPMs) provide useful guidance on the application of phytosanitary measures to the international seed trade.

WELCOME ADDRESS

Mr. MODIBO T. TRAORÉ*

Mr. Chair
Distinguished delegates
Ladies and gentlemen,

It is an honor for me to welcome you to the Food and Agriculture Organization for the second World Seed Conference and I also take this opportunity to welcome our partners for this conference – the Organisation for Economic Co-Operation and Development (OECD) Seed Scheme, the International Union for the Protection of New Varieties of Plants (UPOV), the International Seed Association (ISTA) and the International Seed Federation (ISF) and I commend them for their role in organizing a very important and timely conference.

I am very pleased with the theme you have chosen for the Conference. Indeed, the whole agricultural community is facing many daunting challenges, with over one billion hungry people in the world, a growing threat to food production from climate change, increasing drought, pests and decreasing gains in productivity. No doubt we will have to respond to these challenges urgently and decisively and ensure that food production can double without depleting or destroying natural resources.

Mr. Chair,

As you know, seeds and plant genetic resources are central to the biological basis of agriculture. A strong seed system with linkages between all stakeholders is essential for delivering quality seeds and improved crop varieties which in turn are crucial for global food security and the survival of rural communities. Farmers also play a key role in this process.

In order to guarantee access to the quantity and quality of seeds needed, systems must be put in place to safeguard plant genetic resource management, national varietal development programs and linkages with regional and international research Facilities. National seed services must also be strengthened and seed rules and regulations harmonized at the sub-regional and regional levels to facilitate the trade in seeds. Policies should be developed and strengthened through the involvement of relevant stakeholders, both public and private, to ensure the development of entrepreneurial capacity in the seed industry enterprises.

Throughout these two days, your focus will be on how new plant varieties and high-quality seed could help in mitigating the consequences of global change and meet the need for food security. I note that you have a range of sessions on a variety of themes from the role of plant breeding; the importance of plant genetic resources for plant breeding and benefit sharing; the importance of quality seed in agriculture, to the facilitation of trade and market development. In all these discussions, you will need to offer guidance on a way forward that will be mutually beneficial to both the developed and developing countries as well as to both private and public sectors.

The FAO is heavily engaged in seed sector development and emergency initiatives to improve the food security of vulnerable households and we are also increasing our efforts to promote plant breeding capacity building. We look forward to your advice on how to further strengthen seed systems at the national, sub-regional and regional levels to ensure continued food security and provide an effective response to the challenges facing us, including those related to climate change.

Mr. Chair, distinguished delegates, ladies and gentlemen, I wish you a successful and productive meeting and I look forward to the results of your deliberations,

* Assistant Director-General, Agriculture and Consumer Protection Department

OPENING ADDRESS

Mr. BERNARD LE BUANEC

During the first World Seed Conference held in Cambridge in 1999 it was seen how new plant varieties and quality seed were important to meet the challenges humankind was facing. Ten years later, our changing world continues to provide many challenges for agriculture.

The global population continues to grow and, according to revised UN statistics, should increase from 6.8 billion today to just over 9 billion in 2050. Demand for food will also increase dramatically due to quantitative but also qualitative needs. It is generally considered that crop production will have to increase by more than 50 per cent in the next 25 years to meet the demand.

The level of urbanization will reach almost 70 per cent in 2050, up from 50 per cent this year, putting more pressure on each farmer to feed the urban population. Meanwhile the area per inhabitant will continue to decrease from 0.25 hectares today to 0.15 hectares in 2050. In addition, the decision by many governments to encourage the production of first generation biofuels means that more land will be necessary for crop production. The only way to meet these challenges is to increase significantly the productivity of each hectare of cultivated land.

As shown in the following examples based on national statistical data, yields in various crops and countries have increased regularly during the past decades.

Fig. 1 Evolution of Wheat Yields in France (1805-2005)

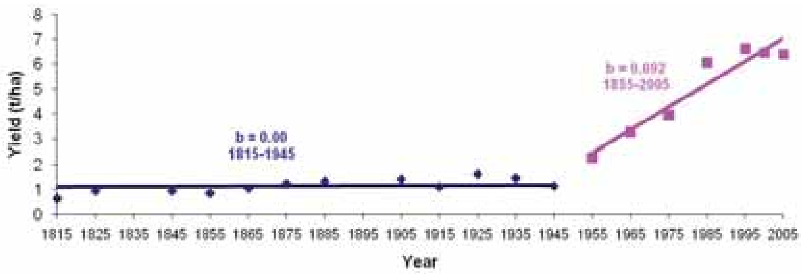


Fig. 2 Evolution of Maize Yields in the US (1866-2006)

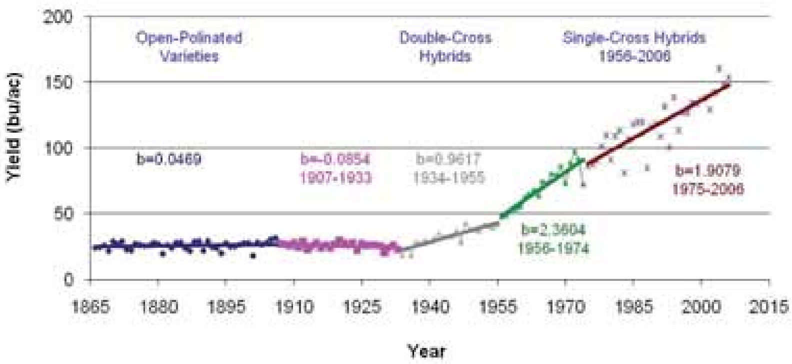


Fig. 3 Evolution of Maize Yields in South Africa.

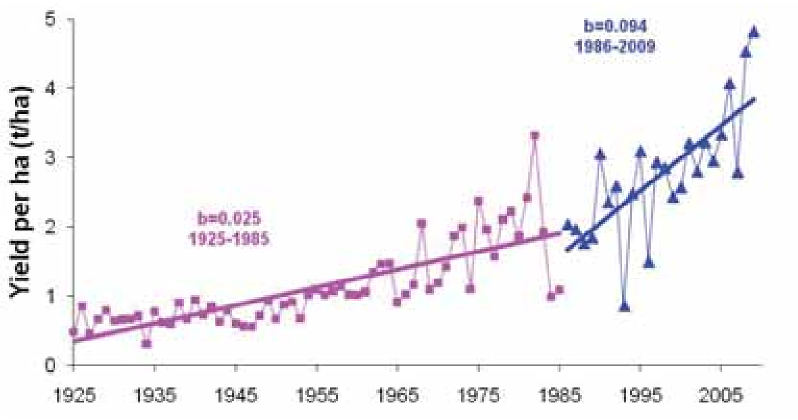
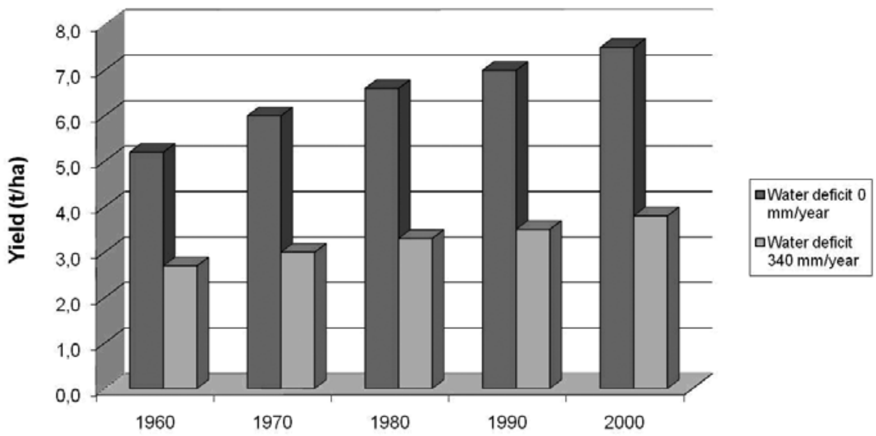


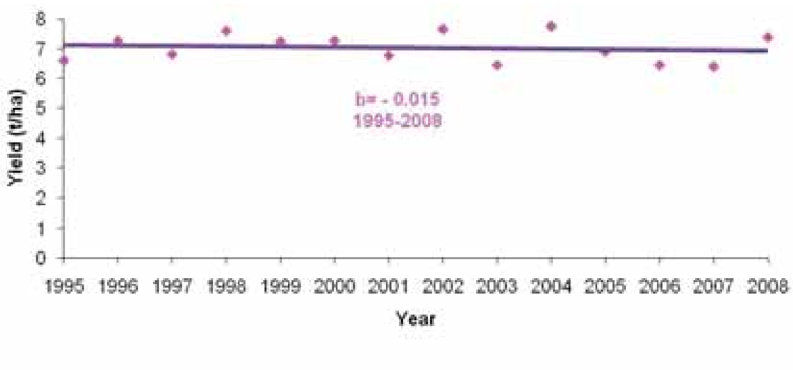
Fig. 4 Evolution of Palm Oil Yields in Ivory Coast



This result is a combination of improvements in plants and techniques of cultivation and the increased rate of adoption of those improvements by farmers. Several authors have shown that, in the long run, half of the yield increase of around 2 per cent per year comes from plant improvement and half from improvement of agricultural practices, in particular the use of fertilizers, crop protection products and irrigation. It is expected that these agricultural inputs will become more scarce and expensive in the future and that plant breeding will become more important.

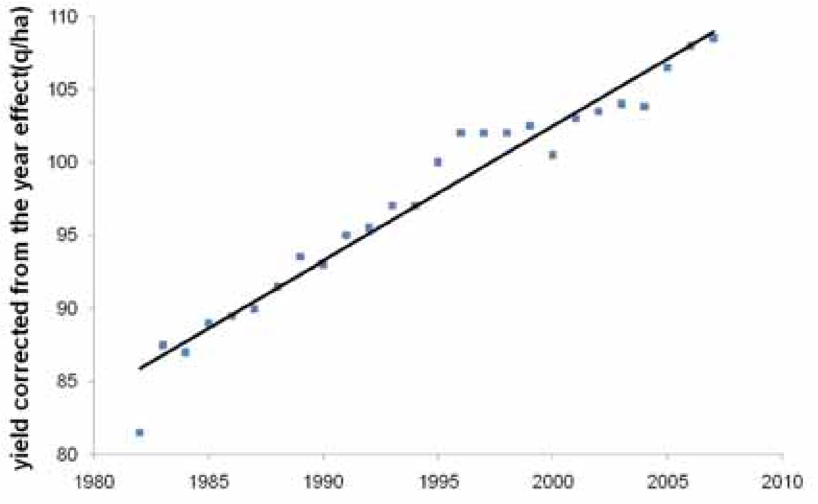
Indeed this evolution has already been confirmed by a recent study in the UK which showed that between 1947 and 1986 half of the yield increase in wheat, barley and oats could be attributed directly to new varieties, but between 1986 and 2006 the new varieties had accounted for a 90 per cent increase. A more detailed look at the evolution of wheat yields in France (Fig.1) gives a similar result. If the global trend from the 1940s to date is a linear increase, the yield seems to have reached a plateau as shown in Fig. 5.

Fig. 5 Evolution of Wheat Yields in France, 1995-2008



This plateau exists despite a continuous genetic gain of around 90 kilos per hectare/per year during the period (Fig. 6). The stagnation in productivity may be explained by a decrease of 10 per cent in nitrogen fertilizers, 25 per cent in crop protection products and by some unusually hot and dry summers.

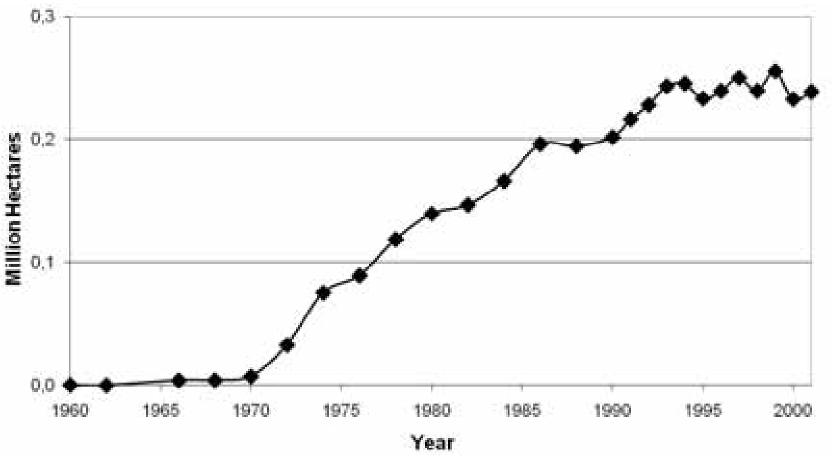
Fig. 6 Wheat Yield Genetic Gain in France, 1995-2008 (after Gilles Charmet in Philippe Gate)



Development of new varieties will be crucial to increase productivity per hectare of cultivated land in the coming years.

Plant breeding can also help crops to adapt to different climatic conditions: before the 1960s, maize was not grown in temperate climates above the 46th parallel. The development of new early maturing varieties has allowed the cultivation of maize up to the south of Sweden. The case of the Netherlands demonstrates the adaptation of a tropical crop to a temperate climate (Fig. 7).

Fig. 7 Adaptation of Maize to a Temperate Climate: the Case of the Netherlands.



It is also possible to adapt temperate crops to tropical climates: for example after 10 years of breeding and selection, varieties of sugar beet, a temperate crop, have been developed for cultivation in tropical climates. These varieties are at the moment under large scale experiment in India. Compared to sugar cane, tropical sugar beet offers several advantages such as lower water consumption, higher tolerance to drought and salinity and shorter growing cycles.

From the above examples it is possible to conclude that plant breeding will be essential to meet future challenges, i.e. to increase the productivity of cultivated land in a context of climate change.

Countries will have to put in place an enabling environment to encourage plant breeding in particular by facilitating access to plant genetic resources and by protecting intellectual property.

However, developing new plant varieties is not enough. They are useless if high quality seed of these varieties does not reach farmers or if farmers cannot afford to buy it. This is why it is necessary to establish sound seed systems allowing for improvement, maintenance and control of seed quality and, where necessary, facilitating trade and market development.

In this period of growing concern about global food security, the Food and Agriculture Organization of the United Nations (FAO), the Organisation for Economic Co-Operation and Development (OECD), the International Union for the Protection of New Varieties of Plants (UPOV), the International Seed Testing Association (ISTA) and the International Seed Federation (ISF) considered it was time to organize this 2nd World Seed Conference with the objective of identifying the key elements necessary to ensure a suitable environment for the development of new varieties, the production of high quality seeds and their delivery to farmers.

Session 1

THE ROLE OF PLANT BREEDING IN MEETING THE MULTIPLE CHALLENGES OF A FAST-CHANGING WORLD

Chairperson: MR. ORLANDO DE PONTI,
President of the International Seed Federation (ISF)

- **The evolution and contribution of plant breeding to global agriculture**
  Mr. MARCEL BRUINS, Secretary General, ISF

- **Anticipated demands and challenges to plant breeding and related technologies into the future**
  Mr. MARCEL BUSUMA KANUNGWE, Director, Pannar Seed Ltd. (Zambia)

- **Effective use of modern biotechnology and molecular breeding and associated methods as breeding tools**
  Mrs. USHA BARWALE ZEHR, Director of Research, Mahyco (India)

- **The opportunities presented by modern biotechnology to enhance plant breeding – what's in the pipeline?**
  Mr. WILLIAM S. NIEBUR, DuPont Vice President, Crop Genetics Research & Development, Pioneer Hi Bred International, Inc., A DuPont Company (United States of America)

- **Building capacity for plant breeding in developing countries**
  Mr. ELCIO GUIMARAES, Senior Officer (Cereals and Crop Breeding), Crop and Grassland Service (AGPC), FAO

General discussion

Conclusion, presented by the Chairperson

THE EVOLUTION AND CONTRIBUTION OF PLANT BREEDING TO GLOBAL AGRICULTURE

Mr MARCEL BRUINS*

Summary

Domestication of crops started some 11,000 years ago and since then much progress has been made. In this paper, the history of plant breeding and the seed industry is discussed, together with the most important developments in this sector. Plant breeding has made an enormous contribution to global agriculture (yield, resistance to biotic stress, tolerance to abiotic stress, harvest security, improvement of quality traits including nutritional value, etc.). Yield in many crops has increased from 1 to 3 per cent per year. A large proportion (50 to 90 per cent) is due to improved varieties, rather than to other input factors, and in certain crops this percentage is increasing. The efforts of plant breeders have led to varieties with increased resistance to biotic stress, saving many millions of dollars in crop protection products per year, as well as to varieties with increased tolerance to abiotic stress, such as drought, salinity, flooding or herbicides.

Plant breeding is an activity that requires a considerable amount of skill and financial investment to support the lengthy and risky processes of research and product development such as intellectual property (IP), which is crucial for a sustainable contribution to plant breeding and seed supply and mechanisms need to be in place to ensure a return on investment. Plant breeding and related disciplines and technologies have the ability to significantly contribute to solving several possible future problems such as food insecurity and hunger, high input costs, etc. They can also offer increasing nutritional values and other traits useful for mankind. This is how plant breeding is mitigating the effects of population growth, climate change and other social and physical challenges.

Introduction

Broadly speaking, plant breeding could be considered to be changing the genetic make-up of plants for the benefit of humankind. More specifically, it is developing new varieties through the creation of new genetic diversity, by reassembling existing genetic diversity all with the aid of special techniques and technologies.

The precursor to plant breeding as we know it today began 9,000 to 11,000 years ago when man domesticated wild plants. By a process of trial and error, plants with desirable traits were selected – the process often referred to as domestication – rendering them more suitable for agriculture. Within a relatively short time frame of several thousand years, all the major cereal grains, legumes, and root crops have been domesticated. These are the food crops that mankind has depended on most for its calorie and protein intake.

Source, Crispeels, 2008

* Secretary General of the International Seed Federation (ISF)

Since then, there have been many noteworthy break-throughs in plant breeding and promising research activities to raise yields in marginal production environments are ongoing. Today, plant breeding uses techniques from simple selection to complex molecular methods to integrate desirable traits into existing varieties to meet human needs. Whether carried out by the public or private sectors, plant breeding is an activity that requires skill and financial investment to support the lengthy and risky process of research and product development.

Plant breeders work with all kinds of crops, such as agricultural (or field) crops, horticultural crops (including ornamentals), forage and turf crops and forest crops. Crops producing medicines or providing environmental remedies are also within their sphere of action. In order to find and create enough genetic variation, they are involved in the collection of germplasm around the world. They preserve, evaluate and distribute the germplasm to those interested in working with the crop. The products of plant breeding can be found everywhere in the form of new varieties of useful crops for growers, farmers, and gardeners. Plant breeders develop new cultivars which give higher yield, earlier maturity, better adaptation, improved quality, and higher resistance to disease, insects, and environmental stress, just to name a few of the characteristics that benefit mankind.

It is mainly the plant breeders, along with other agricultural researchers and extension services, who have provided the world's population with plentiful food, improved health and nutrition and beautiful landscapes. Agriculture can be considered to be the foundation of civilization, and in a similar way, plant breeding can be considered to be the foundation of agriculture.

The International Seed Federation (ISF) represents the seed industry, and therefore this paper will mainly focus on its contribution to global agriculture.

The Seed Industry – a Time Line

Crop improvement until recently, was in the hands of farmers: Darwin and Mendel in the late 19th century laid the cornerstones for modern plant breeding. During the 20th century knowledge of genetics, plant pathology and entomology has grown and plant breeders have made an enormous contribution to increased food production throughout the world.
The commercial seed industry started around the 1740s with the establishment of the earliest known seed company Vilmorin (1743), followed by Tezier (1785), Groot (1813), Comstock (1829), Takii (1835) and several others. The 1850s saw the involvement of the public sector not just in plant breeding but also in the protection of the interests of farmers and consumers: this was also the period that saw the birth of modern plant breeding. New companies such as KWS (1856), Asgrow (1865), Sluis and Groot (1867), Royal Sluis (1868), Weibull (1870), Vander Have (1879), Clause (1891) and many others were established.

The first national seed associations such as the American Seed Trade Association (1883), the Dutch Seed Association (1909), the Polish Seed Association (1919), the Italian Seed Association (1921) and the Canadian Seed Trade Association (1923), to name just a few, were also established.

From 1900 the seed industry entered a period of transition and modernization. The seed sector, both public and private, continued to grow and science and commerce expanded. In the first decades of the 20th century seed traders felt a clear need to establish harmonized trade rules, and this led to the establishment of the International Seed Trade Federation (FIS) in 1924. The desire to protect the fruits of their labor led plant breeders to form the International Association of Plant Breeders (ASSINSEL) in 1938.

Around the same time, several international bodies were created for setting standards and regulations that provided an enabling environment for the seed industry: the International Seed Testing Association (ISTA) in 1924; the International Plant Protection Convention (IPPC) in 1951; the OECD Seed Schemes in 1953 and the International Union for the Protection of New Varieties of Plants (UPOV) in 1961.

In the late 1960s and 1970s in the industrialized countries, a first wave of consolidation in the seed industry was witnessed where chemical corporations and the oil industry began acquiring seed companies. During the 1980s, biotechnology, mainly in the form of DNA marker-assisted selection and genetic engineering, was being used more and more by seed companies. A second wave of consolidation took place in the 1990s with the establishment of the so-called "life science" companies. It should be noted that many small and medium-sized breeding companies were also established.

On the regulatory side, it is worthwhile mentioning the revision of the UPOV Act in 1991 which introduced, inter alia, the concept of Essentially Derived Varieties (EDV); the entry into force of the Convention on Biological Diversity (CBD) in 1993; the signing of the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS Agreement) in 1994 and the establishment of the World Trade Organization (replacing GATT) in 1995. In 2000, agreement was reached on the Cartagena Protocol on Biosafety, which entered into force in 2003. Last but not least, and of particular interest to the seed industry, negotiations on the International Treaty on Plant Genetic Resources for Food and Agriculture (IT-PGRFA) ended in 2001 and it entered into force in 2004.

Annex 1 gives a time line showing significant events for the seed industry.

The Seed Industry Today

This can be characterized by the following developments:

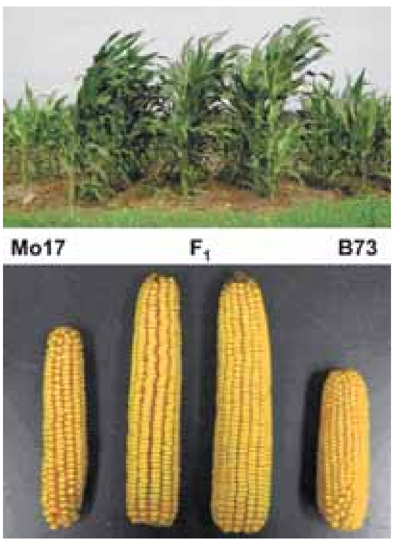
a. An increasing global seed market
b. A growing use of hybrid seeds with several technological components
c. A growing international seed trade
d. An increasing number of regulations
e. An increasing number of multinational companies

a. An Increasing Global Seed Market

The global seed market increased from around 12 billion US dollars in 1975 to around 20 billion US dollars in 1985 and was estimated at 36.5 billion US dollars in 2007. This increase in size is mainly caused by the following factors:

- *Development of Hybrids.* The first hybrids that appeared on the market were corn hybrids in the 1920s. The commercial release of other hybrid varieties started in the mid-1950s with sorghum in 1955, sugar beet in 1962, rice in 1973, rye in 1984, oilseed rape in 1985 and alfalfa in 1998. The first cotton and vegetable hybrids appeared on the market in the 1970s.

  Hybrids offer several advantages to farmers. Due to the effect of heterosis or hybrid vigor, these varieties often outperform the best parent lines, and, in addition, hybrids are highly uniform, another of their characteristics being that they cannot be selfed without changing the genetic characteristics of the variety.



Source: Genome Res. 17: 264-275

- *Increasing Use of Seed Treatment*. The first mention of seed treatment dates back 4,000 years: onion or cypress sap was used on seeds in Egypt, Greece and parts of the Roman Empire around 2000 BC. Salt water treatments have been used since the mid-1600s and the first copper products were introduced in the mid-1700s. Other key milestones were the introduction of arsenic, used from 1740 to 1808, and mercury, used from 1915 to 1982. Up to the 1960s seed treatments consisted only of surface disinfectants and protectants. The first systemic fungicide product was launched in 1968 (ISF, 2007).

  Seed treatment greatly reduces the area of land in contact with a crop protection product, from 10,000 sq. meters for foliar application or 500 sq. meters for furrow application to only 50 sq. meters when the seed is treated. For example, the application rate for an insecticide for corn sown at a rate of 100,000 seeds per hectare reduces from 1,350 grams active ingredient per hectare (ai/ha) for foliar application to 600 grams ai/ha for furrow application and to 50 grams ai/ha for seed treatment (ISF, 2007).

- *Development of Biotech Varieties.* Crops derived with the help of biotechnology were first introduced in 1994 with the "Flavr Savr" tomato variety. They are now grown by more than 13 million farmers in 15 developing and 10 industrialized countries. Biotech crops have shown an increase in yield: Bt cotton yields in China for instance increased by 10 per cent and in India by 31 per cent. Yield increase of Bt maize varieties in South Africa was on average 11 per cent and yield increase of Bt canola in Canada was 10 per cent (James, 2008).

  Biotech crops have also led to a reduction in the use of insecticides; in India and China alone this is estimated to be on average more than 50 per cent. In addition, biotech crops have led to an increased income for farmers. Studies show increased incomes per hectare of 250 US dollars in India, 220 US dollars in China, 117 US dollars in South Africa and 135 US dollars in the Philippines.

  The value of the biotech seed market increased from 115 million US dollars in 1996 to over 7.5 billion US dollars in 2008 (James, 2008).

- *Development of New Markets, especially in Developing Countries*. The estimated value of the world domestic market for seeds has grown from little over 13 billion US dollars in 1979 to well over 36 billion US dollars in 2007, close to a three-fold increase. In several countries the domestic seed market has grown much more vigorously; for example, China had a domestic market of 550 million US dollars in 1979 and it was estimated to have grown to 4 billion US dollars in 2007, a striking seven-fold increase. ISF estimates show other notable rises in Argentina (4.5-fold), Turkey (4.1-fold) and India (four-fold).

b. A Growing Use of Hybrid Seeds with Several Technological Components

As a result of the advantages of hybrid seeds for farmers (see A.), companies have tried to convert crops from open-pollinated or self-pollinated varieties to hybrid varieties. Several important food crops are now mainly sold in the form of hybrid varieties. Notable exceptions are wheat, lettuce, beans and peas which are still mainly self- or open-pollinated. In these crops it has not yet been possible to develop hybrid varieties as a result of technical or economic barriers.

Due to their improved characteristics, these hybrid seeds justify the addition of other components that enhance their potential. The seed price of such hybrid varieties not only includes the value of the genetic material, but also that of several other technological components, such as calibration and other physical improvements: priming, disinfection, chemical treatment (e.g. with fungicides or insecticides) and pelleting or coating. Estimates indicate that in vegetables on average 60 per cent of the price is related to genetics, whereas the remaining 40 per cent is based on other components. When the technology fee that is charged for certain biotech varieties is included, the share of the genetic component in the total seed price could be as low as 30 per cent.

c. A Growing International Seed Trade

The international seed trade grew from a little under 1 billion US dollars in 1970 to around 6.4 billion US dollars in 2007. More and more seed is being moved across borders and the main factors for this increase are:

- Transportation has become cheaper and faster, reaping the benefit of favorable climatic zones such as the East African plains and Idaho (US) for beans or the high plains of Central and South America for flowers.
- The development of hybrid varieties has also led to an increase in more seeds moving across borders. Production of hybrid seeds needs specific conditions both in terms of skilled labor and agro-climatic conditions. For example, the flowering time-difference between male and female maize hybrids requires specific climatic conditions; the production of hybrid vegetables requires skilled labor at a reasonable cost. Thus, for example, hybrid maize in Europe is mainly produced in France, Hungary and Austria, hybrid vegetables in South East Asia and monogerm sugar beet in France, Italy and Oregon (US).
- Finally, the rate of breeding and other commercial processes is more rapid, leading to the development of counter-season production in other hemispheres.

d. An Increasing Number of Regulations

To achieve any significant progress in agriculture, the availability of high-quality seed of the improved varieties at a reasonable price is a prerequisite. Significant changes in plant breeding, seed multiplication and trade have been brought about by modern agricultural practices combined with the establishment of the WTO and TRIPS, including Plant Breeders' Rights (PBR). As more and more seed is being moved around the globe, regulations have been put in place to guarantee a sustainable supply of high quality seed. As a result, the industry today is faced with more and more regulations, particularly in intellectual property and variety registration, seed certification and phytosanitary matters. Recent developments show a rise in regulations in relatively new sectors such as organic seeds, biotech varieties and chemically treated seeds.

e. An Increasing Number of Multinational Companies

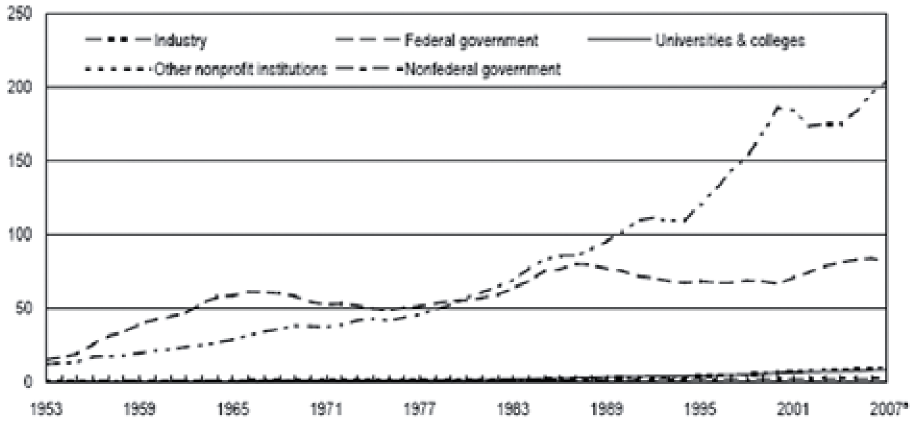
Over the last two decades there has been a significant concentration in the commercial seed industry mainly in industrialized countries. According to calculations made by the ISF, in 1985 the 10 largest seed companies accounted for approximately 12 per cent of the market, increasing to almost 40 per cent in 2007. The major factors responsible for this situation are:

- The increasingly sophisticated technologies used in plant breeding which require substantial investment in research, development and seed production and where economies of scale through mergers have been necessary.
- A need to speed production has caused a loss of specificity of various steps in breeding and a resulting vertical integration of the seed industry. Companies specializing in either breeding or production have decided to integrate their businesses.
- A certain synergy through which R&D is shared across multiple product lines.
- Barriers to entry created by different regulations.

It must be noted that the seed industry is still relatively fragmented when compared with other providers such as the crop protection industry where the top 10 companies represent more than 85 per cent of the market (ETC, 2005).

The possibilities offered by IP protection of plant varieties and biotechnological inventions have encouraged companies to increase their spending on R&D: the plant-breeding industry spends on average 10 to 15 per cent of its annual turnover on this. In contrast, public spending on research and teaching has grown at a much slower rate since the oil crisis of 1973 led to an economic crisis in the western world, making it more difficult for states to maintain their levels of funding. These two factors combined have contributed to a growing divide in the percentage of R&D spending between the private and public sectors (Fig. 1).

Fig. 1 R&D Expenditure by Source of Funding in the US: 1953-2007



* Figures for 2007 are estimates.

Source: National Science Foundation, Division of Science Resources Statistics, National Patterns of R&D Resources (annual series).

In this respect it should be noted that ISF members are unanimously in favor of strong and effective IP protection to ensure an acceptable return on research investment, which is a prerequisite to encouraging further research efforts and essential to meet the challenges mankind has to face in the coming years, such as feeding an increasing population while preserving the planet. All of these endeavors require substantial, long-term and high-risk investment.

In the countries where plant varieties can be protected, a UPOV or UPOV-type system is available. There are a few countries where protection through utility patents is also possible and the ISF considers both systems to be legitimate. If a country envisages the adoption of a sui generis system to protect plant varieties, the ISF recommends that this has at least to conform to the requirements of the 1991 Act of the UPOV Convention (ISF, 2009).

ISF members also consider that breeders' rights (and patents for plant varieties where allowed by law) and patent protection for biotechnological inventions offer good protection. It is thus necessary to define fair coexistence of the two rights. The introduction of the concepts of essential derivation and dependency in the 1991 Act of the UPOV Convention is a welcome initiative to this end and is in the interests of everyone.

However, further clarification is needed as regards the use of biotech varieties containing patented elements and protected by breeders' rights for further breeding. ISF members are strongly attached to the breeders' exception provided for in the UPOV Convention and have expressed their concern that the extension of the protection of a gene sequence to the relevant plant variety itself could extinguish this exception.

ISF members therefore consider that a commercially available variety protected only by breeders' rights and containing patented elements should remain freely available for further breeding.

If a new plant variety, not an essentially derived variety resulting from further breeding, is outside the scope of the patent's claims, it may be freely exploitable by its developer. On the contrary, if the new developed variety is an EDV or if it is within the scope of the patent's claims, consent from the owner of the initial variety or the patent must be obtained (ISF, 2009).

Contribution of Plant Breeding

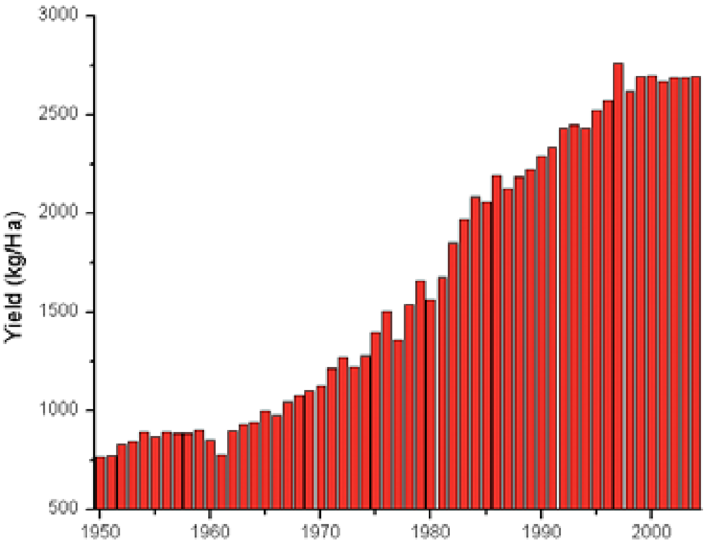
Numerous contributions have been made by plant breeding and over the years plant breeders have focused on increasing the yield of varieties, on resistance to biotic stress and tolerance to abiotic stress. Other factors that have been altered for the benefit of mankind are: earliness, taste, size, nutritional and crop quality, firmness, shelf-life, plant type, labor costs and harvestability.

Yield

Arguably the most important of all characteristics is yield. Studies in different crops over many years show that yield has increased from 1 to 3 per cent per year. At first sight 1 per cent may not seem much, but when added up over many years it is a significant contribution. Over the past 30 years, in irrigated wheat, a yield increase of about 1 per cent per year has been achieved, which can be compared to an increase of around 100 kg per hectare. per year (Pingali and Rajaram, 1999).

This yield increase is not restricted to industrialized countries: FAO data for all developing countries indicate that wheat yields rose by 208 per cent from 1960 to 2000; rice yields rose 109 per cent; maize yields rose 157 per cent; potato yields rose 78 per cent; and cassava yields rose 36 per cent (FAOSTAT).

Fig. 2 Wheat yields in developing countries, 1950-2004



Source: FAO

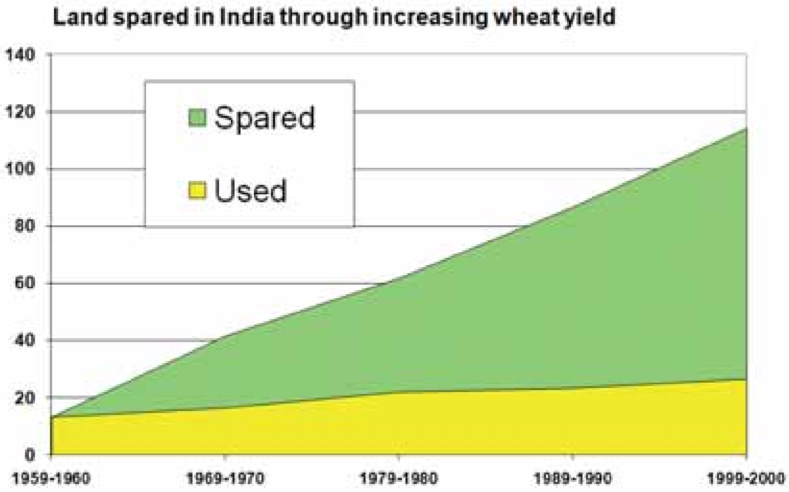
Winter wheat yields in the UK have more than trebled over the past 60 years from around 2.5 tonnes/hectare in the mid-1940s to 8 tonnes/hectare today. To determine the effect of genetic improvements on the total yield increase, the National Institute of Agricultural Botany (NIAB) in the UK carried out a study in 2008 in which 300 varieties of wheat, barley and oats were analyzed in 3,600 trials, leading to 53.000 data points. Previous studies had already indicated that in the period 1947 to 1986 about half of the increase in yield could be attributed to plant breeding: the rest of the increase was due to improvements in fertilizer, crop protection products and machinery. The 2008 analysis revealed that in the period between 1982 and 2007 in which yields went up from 5 to 6 tonnes/hectare to 8 tonnes/hectare, over 90 per cent of all yield increase could be attributed to the introduction of new varieties. This clearly shows the contribution of the genetic component to yield increase.

Land Spared

Because yield has increased steadily over the years, plant breeders have contributed to a saving in the use of land which would otherwise have been needed to achieve the same level of production.

For example: India's cereal production increased from 87 million tonnes in 1961 to 200 million tonnes in 1992 on an arable land base that has remained almost constant, and in that way has helped to limit the extension in land use . Between 1950 and 2001, the world's population grew from 2.5 billion to 5.5 billion, although the land devoted to agriculture remained stable at around 1.4 billion hectares. It has been calculated that 26 million square kilometers of land were saved and this will certainly increase in the future (CLI, 2001). This means that deforestation has decreased and biodiversity has been maintained.

Fig. 3 Amount of Land saved in India in Millions of Hectares in the Period 1959-2000



Biotic Stress Resistance

According to FAO data, the current annual loss worldwide due to pathogens is estimated at 85 billion US dollars and to insects at 46 billion US dollars. Therefore it is not surprising that a considerable amount of effort goes into breeding for biotic stress resistance. This involves, inter alia, resistance against fungi, bacteria, nematodes, viruses, water moulds and insects. Over the years breeders have released thousands of varieties with as much or higher resistance. In that way they have given farmers the necessary harvest security to ensure that they have a crop to harvest at the end of the growing season.

With this breeding for biotic stress resistance, there has been significantly less need to use crop protection products, resulting in a significant decrease in the environmental footprint made by agriculture. It has been calculated that in the UK alone, disease resistance saves 100 million pounds sterling per year on crop protection products (BSPB, 2009).

However, it should also be said that there is still a lot of work to do. For example fully resistant varieties against three fungal diseases affecting cereals and grasses, Fusarium head blight (FHB), ergot and stem rust, are still needed. It is estimated that FHB causes an annual loss of 1 billion US dollars in wheat yield and grain quality. Reports indicate that in a state such as North Dakota (US) a loss of up to 10 per cent can occur in wheat due to ergot infection, and losses of 5 per cent are common in rye. With the Ug99 strain of stem rust, 100 per cent crop loss has been reported. These are just a few of the examples where the continuous and relentless efforts of plant breeders are desperately needed.

Abiotic Stress Tolerance

Ninety million people per year are affected by drought, 106 million people per year are affected by flooding and around 900 million hectares of soil are affected by salinity. In addition, according to FAO data, the current annual loss worldwide to weeds is a staggering 95 billion US dollars. Of this, around 70 billion US dollars is lost in developing countries, which is equivalent to a loss of 380 million tonnes of wheat.

Plant breeders have also worked on tolerance to abiotic stress factors such as herbicide tolerance, drought, flooding and salinity. In the case of poor soils, breeders have attempted to select varieties which were better capable of taking up the necessary nutrients. When considering the possible effects of climate change, certain areas are expected to see a decrease in the level of rainfall, whereas other areas could expect the reverse. Plant breeders will therefore continue to research and create new genetic variations to develop the necessary germplasm to cope with these challenges.

The figures given above underline the magnitude of the task ahead and the need to have a good plant breeding infrastructure and seed industry in place.

Nutritional Quality

The concept of nutritional quality is fairly new but is becoming more and more important. As an example, around 124 million people annually in 118 countries are affected by vitamin A deficiency leading to 1-2 million deaths and causing blindness in around 500,000 children each year. Rice is a staple food crop for about half of the world's population and it was no surprise that this crop was chosen to try and introduce carotenoid levels in the rice grain. Rice varieties with high levels of beta carotene, the precursor of Vitamin A were developed and were named "golden rice". It is interesting to note that around 70 intellectual property rights (IPRs) from 32 companies were relinquished to make this commercially possible and market release is planned for 2011 (www.goldenrice.org). Other interesting developments are, for example, varieties of broccoli with higher levels of the cancer-fighting compound glucosinolate, or tomatoes with higher levels of the anti-oxidant lycopene.

Crop Quality

Plant breeders have adapted crops in many different ways, and here are a few examples. Brussels sprout hybrids have been developed with uniform ripening and size to make them suitable for machine harvesting; monogerm sugar beet varieties have been developed, thus reducing the need for laborious thinning and enabling fully mechanized cultivation; malting quality in barley has been improved, producing 2,000 liters of beer per tonne in 1950 rising to 8,000 liters in 2008. Taste in vegetables has been greatly improved, as well as the number of health components.

The Green Revolution

This can be characterized by the combined use of high-yielding varieties, fertilizer, irrigation, machinery and crop protection products and began in 1945. In the years before the onset of the green revolution, Mexico imported half of its wheat, whereas in the mid-1950s, the country had become self-sufficient and a decade later was able to export half a million tonnes (Dewar, 2007). Agricultural research, extension programs and infrastructural development were also improved (Parks, 2006).

In 1961, India was on the brink of famine (National Geographic Magazine, 2001), but as a result of the green revolution, India's wheat production increased from 10 million tonnes to 73 million tonnes between the 1960s and 2006 (BBC, 2006; CGIAR, 2007). This was accompanied by an increase in land use of only 9 million hectares (from 14 to 23 million hectares). Without the benefits of the green revolution, utilizing the best results of plant breeding, crop protection, irrigation, mechanization and education of farmers, many millions of hectares of habitat would have been plowed under (CLI, 2001).

A few examples of the contributions of plant breeding can be found below. They highlight the benefits of combined public and private efforts toward producing varieties with more desirable traits which will benefit mankind.

New Rice for Africa (NERICA)

Rice is a major food and energy source in large parts of West Africa and currently about 1 billion US dollars of rice is imported annually.

For the past 3,500 years, African rice (Oryza glaberrima) has been cultivated and is well adapted to the African environment. It is resistant to the rice gall midge, rice yellow mottle virus, blast disease and to drought. In addition it has a profuse vegetative growth which keeps weeds at bay. However, this rice type easily lodges and produces relatively low yields. An additional problem is that the grains may shatter and this also decreases the yield. As a result the cultivation of African rice was abandoned in favor of high-yielding Asian varieties (O. sativa) which were introduced into Africa some 500 years ago. However, these Asian varieties require abundant water and are poorly adapted to African conditions as they are too short to compete with weeds and are also susceptible to several of the African pests and diseases.

In an attempt to overcome these problems, the African Rice Center (WARDA) with the help of plant breeders developed new rice varieties by crossing these two types. Normally they do not interbreed so embryo rescue techniques had to be used. Upland and lowland varieties were developed showing heterosis and outperforming the best parents.

One of the main features of these Nerica lines is that yield could be increased from about 1 tonne/hectare to about 2.5 tonnes/hectare. With the use of fertilizer, yields of 5 tonnes/hectare were reached. The new lines have 2 per cent higher protein content, are resistant to pests and are taller than most other varieties, making them easier to harvest. Some of the newly developed lines are giving good results with relatively low amounts of water and could therefore be adapted to drought conditions (Nerica, 2009).

Tropical Sugar Beet

Water shortage is a major problem in many parts of the world and it is a well-established fact that sugar beet can be grown in relatively dry areas as the crop requires substantially less water than sugar cane. In an attempt to provide crops that use less water, plant breeders have developed tropical sugar beet varieties that yield the same quantity of sugar per land unit as sugar cane but use only one third to one half the amount of water. In this way, up to 10,000 cubic meters of water per hectare could be saved.

An additional benefit is that these new varieties grow faster, allowing farmers to grow a second crop in the same period it would take sugar cane to mature. Therefore, in one hectare, about 10 tonnes of white sugar could be produced in five to six months instead of a year. This type of tropical sugar beet could also be cultivated on saline or alkaline soils which would otherwise be unsuitable for cane or other crops. And, last but not least, studies show that the plant removes the same amount of atmospheric carbon in half the time as does sugar cane (Syngenta, 2007).

Water Efficient Maize for Africa (WEMA)

Maize is a major staple crop but in certain areas suffers from drought which makes farming risky for millions of small-scale farmers who rely on rainfall to irrigate their crops.

Plant breeders have recognized drought tolerance to be one of the most important targets of crop improvement programs. The WEMA project is a public-private partnership in which plant breeders are developing drought-tolerant maize using conventional breeding, marker-assisted breeding, and biotechnology. Combined with other efforts such as the identification of ways to mitigate the risk of drought, to stabilize yields and to encourage small-scale farmers to adopt best management practices, it will be fundamental for realizing food security and improving the livelihoods of these farmers (AATF, 2009).

Africa Biofortified Sorghum (ABS)

Sorghum as a crop has a high fiber content and a poor rate of digestibility of nutrients and these are major contributors to low consumer acceptance. Combined with unpredictable rainfall, declining soil fertility, inefficient production systems and biotic and abiotic stress they have caused a decline in its production. Through the use of plant breeding, including related technologies, the ABS project endeavors to develop a more nutritious and easily digestible sorghum containing increased levels of vitamin A, iron, zinc and several essential amino acids, such as lysine. The success of the project could improve the health of 300 million people (Biosorghum, 2009).

There are thousands of other good examples of the contribution that plant breeding has made to global agriculture which unfortunately cannot all be covered in this paper.

Responding to the Challenges

Taking account of the foregoing, it is safe to say that plant breeding has increased food security, in many ways and has contributed to the alleviation of hunger and poverty and resulted in higher nutritional value. Resistant varieties have led to a reduction in the use of crop protection products and in the use of fossil fuels. With certain varieties there is no or less need for plowing, thus decreasing CO2 emissions and improving soil conservation and water content. Increased yields have reduced the need for more land cultivation and have decreased deforestation, contributing to the conservation of biodiversity and better carbon sequestration.

Conclusion

In the words of Nobel Peace Prize winner Norman Borlaug, plant breeders have made an enormous contribution to food production, global agriculture and the general well-being of mankind and have a tremendous potential to continue to do so (Borlaug, 1983). However, this cannot be done without the necessary regulatory and other changes towards providing an environment in which all stakeholders can work together in a mutually supportive way towards a constant supply of high quality seeds.

References

AATF: *http://www.aatf-africa.org/aatf_projects.php?sublevelone=30&subcat=5*, 2009.

BBC: *http://news.bbc.co.uk/2/hi/south_asia/4994590.stm*, 2006.

Biosorghum: *http://biosorghum.org/*, 2009.

Borlaug: *Science*, February 11, 1983: Vol. 219. no. 4585, pp. 689 – 693, 1983.

BSPB: *http://www.bspb.co.uk/BSPB%20Handbook.pdf*, 2009.

CGIAR: *http://www.cgiar.org/newsroom/releases/news.asp?idnews=532*, 2007.

CLI: *Benefits of Using Crop Protection Products with Specific Reference to Habitat Preservation and Biodiversity*, CLI position paper, March 2001.

Crispeels: *Ten Thousand Years of Crop Improvement: from Domestication to Genomics*. Presentation made at the Pan-American Seed Congress in Cartagena, Colombia, October 2008.

Dewar: *http://www.rand.org/pubs/occasional_papers/2007/RAND_OP179.pdf*, 2007.

ETC: *Oligopoly*, Inc. 2005, brochure ETC November/December 2005.

ISF: *Seed Treatment – A Tool for Sustainable Agriculture*. Brochure ISF, October 2007

ISF: *ISF View on Intellectual Property, www.worldseed.org*, May 2009.

James, Clive: Global Status of Commercialized Biotech/GM Crops, ISAAA Brief no. 39. ISAAA: Ithaca, NY, 2008.

National Geographic Magazine, 2001: *http://news.nationalgeographic.com/news/2001/06/0621_bamboo.html*.

Nerica: *www.nerica.org*, 2009.

NIAB: *http://www.bspb.co.uk/newsarticle_2008_06_10a.html*, 2008.

Parks, Walt: “Defining the Green Revolution.” Online, Internet, *http://wparks.myweb.uga.edu/ppt/green/*, September 25, 2006.

Pingali, P.L., Rajaram, S.R.: 1999. *World Wheat Facts and Trends*, 1998/99. CIMMYT Institute, Mexico, DF.

Source ISF: ISF website: *www.worldseed.org*.

Syngenta: *http://www.syngenta.com/en/media/press/2007/08-28.htm*, 2007.

Annex 1 Time Line of Significant Events for the Seed Industry

1859	*On the Origin of Species - Darwin*
1866	*Experiments on Plant Hybridization – Mendel*
1869	Discovery of DNA from nuclei – Miescher
1883	*Paris Convention for the Protection of Industrial Property* – World Intellectual Property Organization (WIPO)
1900	*The Rediscovery of Mendel Laws* – de Vries and Correns
1902	Culture of isolated plant cells – Haberlandt
1904	First embryo culture - Hanning
1908	The discovery of heterosis (hybrid vigor) – Shull
1919	*Identification of the Base, Sugar and Phosphate Nucleotide Units of DNA* - Levene
1920s	Quantitative genetics and breeding developed
1921	First commercial double cross in corn hybrid released
1922	First haploid reported – Blakeslee et al.
1930s	First experiments with seed coating
1933	CMS developed in maize
1939	First continuously growing callus cultures – Gautheret, White and Nobecourt
1943	Confirmation that DNA carries genetic information – Avery, McCleod and McCarthy
1948	Discovery of transposition - McClintock
1950s	Development of tissue culture media – Skoog et al.
1953	Induction of haploid callus from mature pollen grains – Tulecke
1953	Description double-helix structure of DNA – Watson and Crick
1955	First field of hybrid sorghum planted
1958	Development of somatic embryos – Reinert and Steward
1959	First plant regenerated from mature plant cell – Braun
1960	Production of large quantities of protoplasts – Cocking
1961	First RNA base described – Nirenberg and Matthaei
1965	Completion of genetic code deciphering
1964	Embryo formed in anther culture, haploid plants regenerated – Guha and Maheshwari
1960s	Commercial development of seed coating
1968	First systemic fungicide
1971	Commercial seed priming
1972	First somatic hybrid after protoplast fusion – Carlson et al.
1973	Invention of DNA cloning and genetic engineering
1980	Description of the first polymorphic marker
1980	US Supreme Court Chakrabarty decision allowing patenting of living organisms
1977	*Budapest Treaty on the International Recognition of the Deposit of Microorganisms for the Purposes of Patent Procedure* – WIPO
1983	RFLP in plants => molecular marker-assisted selection
1983	Stable transformation of plants by genetic engineering
1985	First transfer of a gene coding for an agronomic trait (herbicide tolerance in tobacco)
1988	First transgenic plant with a "quality" trait (delayed ripening in tomatoes)
1990s	New classes of fungicides, insecticides and nematicides
1994	"Flavr Savr" tomato introduced
1995	Bt-corn introduced, 1.5 million hectares of biotech crops
1996	RR soybeans introduced
2008	125 million hectares planted with biotech crops

Discussion

ORLANDO DE PONTI (ISF): Marcel, it was both in the presentation of Bernard Le Buanec and yourself, and that was new to me, that there has been a shift in the contribution of plant breeding in terms of percentage. For many years I have always mentioned the 50/50 split: there was a 2 per cent yield increase per year, 1 per cent due to genetic improvement, 1 per cent due to, as I say, agronomy. And it was for me quite interesting to note that it has been published that today this is 90 per cent. It was mentioned of course that this is due to the investment in plant breeding, on the other hand, my question is also to you Marcel, whether it also gives a sign, and although this is not the topic of this conference, that maybe the world is not investing enough or taking enough care of the potential of agronomy?

MARCEL BRUINS (ISF): We've seen that investments have been low in all agricultural fields, in all agricultural R&D fields, so also in agricultural technology, in plant breeding, in plant pathology, seed testing, just to name a few. I think agriculture has been taken for granted for too long. It was just there and we have even seen the disappearance of Ministries of Agriculture here and there in certain countries, moving to Ministries of Consumer Affairs and the like. So yes, I do agree that there has been negligence, a lack of necessary investment in that field. I also speculate that maybe at a certain point you reach a level of the maximum attainable yield because of fertilizers. You can only put so many fertilizers on a field. After that it will become harmful to the crops. So I think that might also contribute to the plateau that you see with those other input factors, and that it is now mainly up to genetic improvement to provide us with the necessary yield increase.

BERNARD LE BUANEC (ORGANIZING COMMITTEE): Just a comment on your question as well Orlando. In fact we see at the moment in the world a shift and a very strong demand for decreasing the inputs. And that is for me probably the most important point. But for agricultural practices we are used to high input agriculture and we are moving to low input agriculture. And you have a completely new paradigm to work on and to see how to be efficient with that low input. So we have that and of course plant breeding will be something extremely important. We have to think of a new way of growing crops with low inputs and that is a completely new approach.

ORLANDO DE PONTI (ISF): Thank you, I agree with you. But that of course is agronomy and research because to decrease the input you have to know what you do or what the farmer does. And we all know that we are moving now into what we call precision agriculture but, as you will learn today, also into a time of precision breeding. And the two go together in order to optimize or to maximize yields.

JAI SINGH (ASIA PACIFIC SEED ASSOCIATION): My question to Marcel is: if you see this development so far, it needs a lot of contributions from traditional plant breeding and from now on the private companies are shifting towards biotechnology. How do you anticipate in the future the role of traditional plant breeding? Because if you look at the system now you don't find traditional plant breeders. So how do you see in the future whether this is going to be decreasing or of no relevance or is it all biotechnology from now on?

MARCEL BRUINS (ISF): There needs to be very good cooperation between the public and the private sector, that is becoming clearer every day. I think in certain crops for example, wheat or rice in which private companies until now may not have been so active, it will remain necessary to continue the breeding activities. There you will see the need to keep up a very good public breeding infrastructure to make sure that the necessary germplasm is introduced into partly or fully commercial varieties. The role for public breeding seems to be shifting towards pre-breeding, making sure that through fundamental research the necessary genes are introduced into the material and then half the material is released to private seed companies, where these exist. Of course where these companies are not available, the public seed sector will continue to provide those commercial varieties. And I would not say that biotechnology is just used by the private sector: I have seen a lot of examples where biotechnology has been fully introduced into the public seed sector as well. I don't see that clear split but the need for good cooperation between public and private is clearer than ever.

ORLANDO DE PONTI (ISF): I would like to follow up a little bit on this and get some clarification from you Mr. Singh, because you used the words "participatory plant breeding", and of course we all know it, but I am used to the fact that you get quite a variety of explanations for what it really is. Could you give your explanation of what you feel participatory plant breeding means for your part of the world, as President of APSA, and whether you see potential for it in terms of the challenges ahead?

JAI SINGH (ASIA PACIFIC SEED ASSOCIATION): My concern was actually coming from the South Asian part of the world but if you look 30-40 years back we used to find that very good plant breeders came from the universities or research institutes. But these days if you talk to any university, if you go to any research institute, and especially if you want to recruit typical traditional plant breeders, you don't find them so my concern was that everybody is shifting towards biotech matters; for example marker-assisted breeding and all other biotechnologies, but you don't find the real breeders who can emasculate and pollinate and similar activities. You don't find those breeders in the system currently.

BERT VISSER (CENTER FOR GENETIC RESOURCES, THE NETHERLANDS): I have a similar concern and this relates to some of the opening remarks where, Mr. Chairman, you said that plant breeding is becoming an increasingly interdisciplinary sector. It is based on your report on golden rice and the contribution that this has made to the health of our global population. I'm not going to challenge that. I think that is very important. But it also shows in which direction plant breeding is going. My point is that it is now focusing on rice, as one of our main staples and it is helping us to overcome the problem of vitamin A deficiency, but there is so much more in terms of micronutrients, vitamins that we need from our food. And we cannot go on and correct that by improving rice. We also need to diversify the diet of the global population. My question then is how can it promote investment in all those other crops that can provide a diversified diet on which many people will continue to be dependent and this concerns so many neglected and unutilized crops as we have come to know them? So how can we promote investments in those crops?

MARCEL BRUINS (ISF): I think there is merit in starting with a major staple. You will immediately reach an enormous population with that staple. I should also add that other crops have already been released with improved nutritional quality. I've read several reports where other crops with increased nutritional value have become available. So when those varieties of those major staples have been improved where necessary and are put on the market and traded everywhere, I'm sure we'll see efforts in other, minor crops. But for me it is logical to start with a major staple to reach as many people at the same time as possible.

ANTICIPATED DEMANDS AND CHALLENGES TO PLANT BREEDING AND RELATED TECHNOLOGIES INTO THE FUTURE

Mr. MARCEL B. KANUNGWE*

Introduction

The selection of plants to give higher yields with improved quality has formed the basis of plant breeding since man first domesticated wild plants. The evolving constraints, caused by climate change and the need to feed a growing world population, has brought about the current food crisis and requires a significant improvement in crop yields in a relatively short time. There is a rising demand for the seed industry and governments to utilize both current and new breeding technologies more efficiently, but this can only be done through establishing goals (Fig. 1 shows Pannar Seed (Pty) Ltd's corporate breeding goals for hybrid maize) in collaboration with farmers.

Plant breeding on its own will not deliver the required food increase without the use of supportive technologies such as transgenic technology, irrigation, electricity, plant and equipment, etc.

Robynne M. Anderson summed it up well in her article "Putting Farming First" (Seed World, 2009 Edition) by saying that "the approach starts by focusing on farmers, the tools and information they need to steward land, grow crops, bring in their harvest and then get it to market. New investments, incentives and innovations are needed to achieve greater sustainability while delivering increased agricultural production".

This opinion together with the seed industry's corporate breeding goals already mentioned sum up the demands, challenges and opportunities of the past, present and future for global agriculture in general and plant breeding in particular.

Fig. 1 Corporate Breedings Goals

ULTRA EARLY/DROUGHT TOLERANT	
EARLY/DROUGHT TOLERANT	PAN 4M-19
EARLY	PAN 6363
MEDIUM	PAN 67,53
LATE HIPO	PAN 61,6777
VERY LATE	PAN 69,7M-89
ULTRA LATE	PAN 691,683

Anticipated Demands

Changing Farmers' Needs

Farmers are in general becoming more specific in their demands for farm inputs. This is due to the hostile environments they face and the higher operational efficiency they need to attain economic viability.

* Director, Pannar Seed Ltd, Zambia

The seed industry has the task of meeting farmers' specific needs both in terms of product and information. Further, it has to provide adequate information on product performance consistent with the environment (Figs 2 and 3 give product performance under low- and high-potential growing conditions).

In order to address these needs, the seed industry has set the following goals:

- Developing varieties of all maturities from ultra early to ultra late.
- Providing varieties that will perform well in major growing areas, across seasons and circumstances (erratic rainfall (heavy/late rains) and high altitude).
- Developing varieties with sound agronomic traits (cob, leaf and stem disease resistance, standability and hard grain for storability for small-scale farmers).

Particular attention must be paid to the needs of the latter category of small scale farmers (provision of very early flowering and maturing varieties).

Fig. 2 High And Medium Potential Trials - ART Trials 2007/08 8-11T/Ha

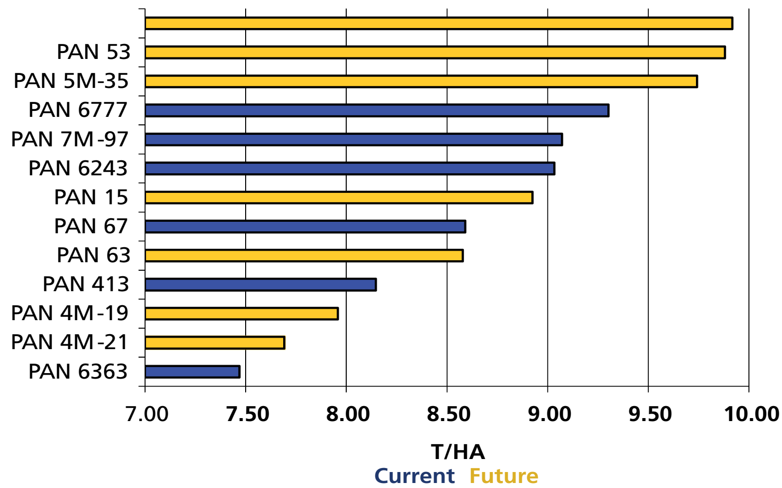
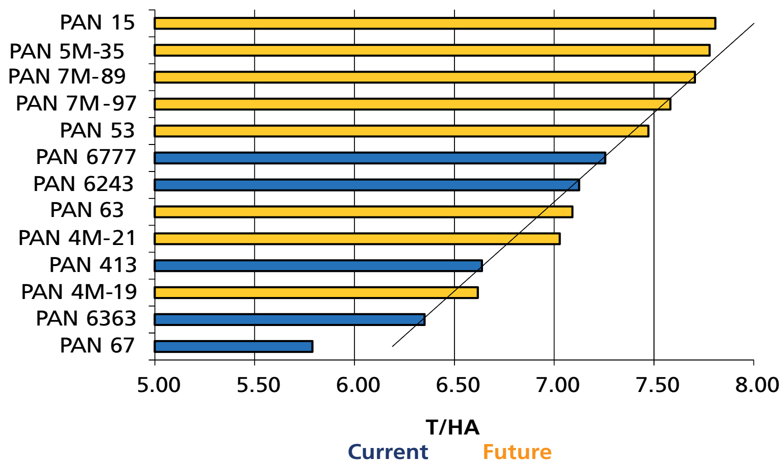


Fig. 3 Medium and Low Potential Trials - ART Trials 2007/08 5-8T/Ha



Development of Infrastructure

Development of infrastructure such as roads, bridges, electricity etc. is a top priority in developing countries as these form the basis for the exploitation of new and advanced technology. One example is the expansion of irrigated land in Indonesia to empower small-scale farmers to produce rice which will maximize output from advanced breeding material.

In sub-Saharan Africa, with vast stretches of land and abundant water resources (rivers and lakes), one would expect the region to have enhanced this potential in order to take advantage of improved varieties.

The common market for Eastern and Southern Africa (COMESA) and the Southern African Development Community (SADC) continue to commit less than 10 per cent of their annual budgets, contrary to an earlier resolution. Unless adequate finance is committed to agriculture, there is little possibility that the present and future agronomic potential of high-yielding varieties will be realized.

Challenges

Population Growth

The present world population stands at 6.8 billion and will reach 9.2 billion by 2050. It is becoming evident that, given a more and more hostile environment to contend with, extra effort will be required to improve plant breeding and supporting technologies will need to be implemented to produce more food. Figs 4a, 4b and 4c show development and deployment of high-yielding maize hybrids at all levels of maturity, from which it will be observed that new products are providing a significant increase in mean relative yield (MRY) over current products.

Fig. 4a Medium hybrids > 8t/Ha

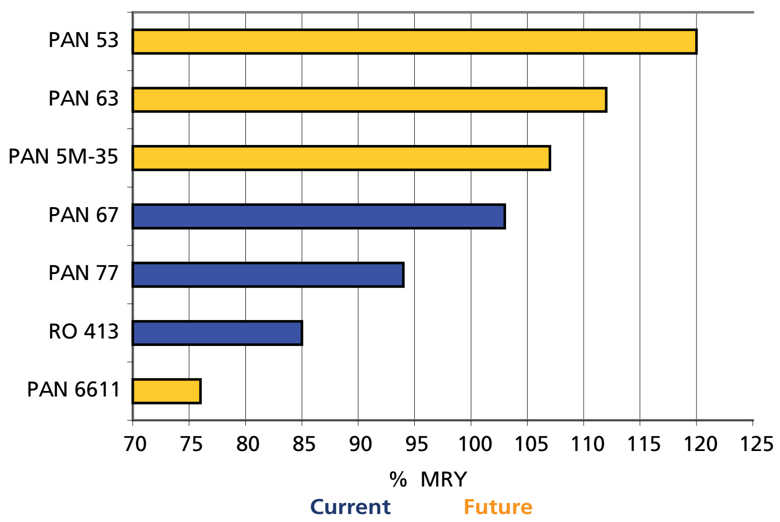


Fig. 4b

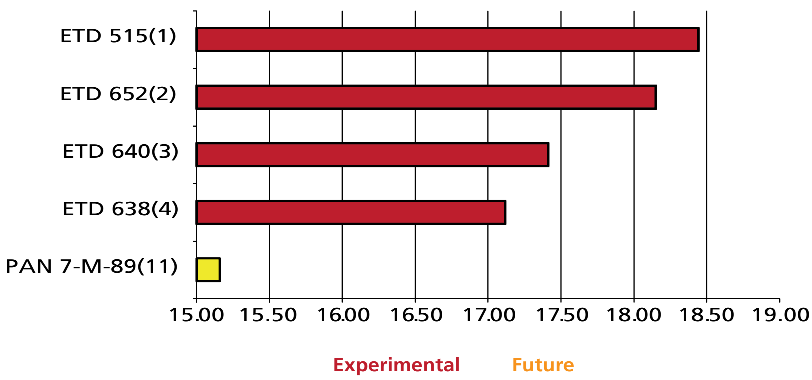
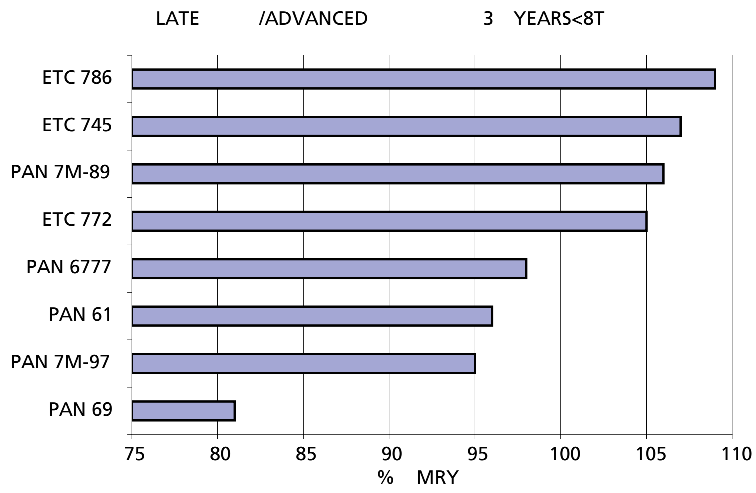


Fig. 4c **Late / Advanced 3 years < 8T**



Access to Suitable Germplasm

Taking account of the different environments, we consider that new products will lead to better agronomic performance in addition to offering increased overall yield.

Stress factors such as drought, high temperature and high precipitation are taken into consideration in breeding programs. Germplasm stability is critical and is shown in Figs 5 and 6; maize does better with medium rainfall. Achieving good results with the same products in conditions of high or erratic rainfall will mean expanding production areas.

High altitude areas are being brought into focus and suitable germplasm is being screened and put into production.

Fig. 5 **High Rainfall - Commercial Hybrids**

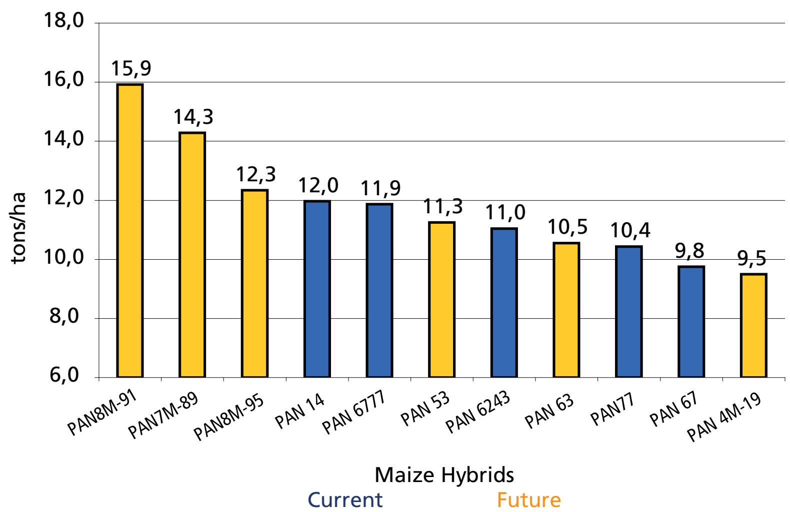
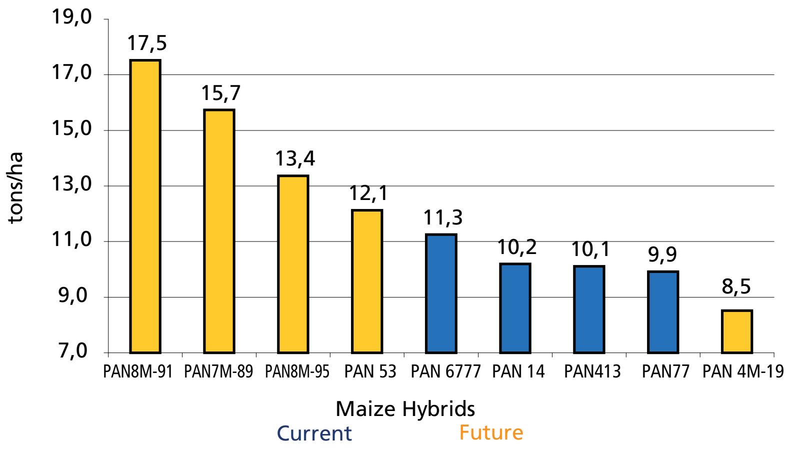


Fig. 6 Medium Rainfall - Commercial Hybrids



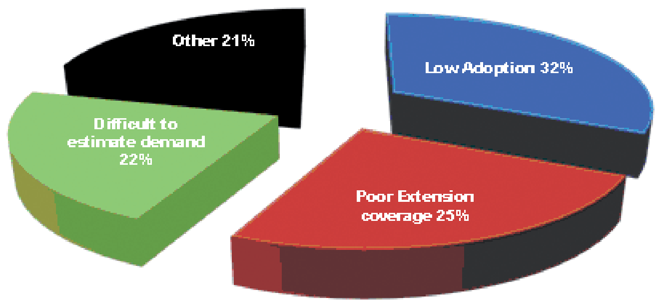
Low Seed Demand at Farm Level

It can safely be stated that, at its current level of development, the available germplasm is capable of producing enough food for the present world population. However, in developing countries which are now facing a food crisis, farmers are not readily adopting new improved varieties and are therefore being deprived of their benefits.

Fig. 7 shows low take-up of improved varieties in Eastern and Southern Africa. This is attributed to:

- Poor coverage by extension services and lack of up-to-date information on varieties and services available.
- Farmers are unaware of the availability of improved varieties that can increase productivity.
- Farmers make decisions without being aware of varietal characteristics.
- Seed companies are unable to forecast demand.
- Other factors such as poor access to credit and lucrative markets handicap farmers in the developing world.

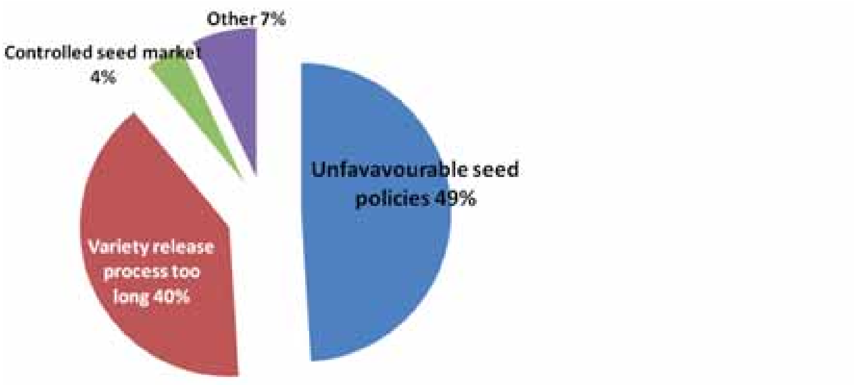
Fig. 7 Bottlenecks influencing Farm level seed demand



Seed Control and Certification Legislation

Seed policy or its absence has in many instances, particularly in developed countries, impacted negatively on development of the seed industry and agriculture in general. Fig. 8 illustrates the principal bottlenecks which limit seed production and distribution in Africa.

Fig. 8 Major Seed Policy Related Bottlenecks Hindering the production and distribution of seed in Africa (DTMA Seed sector survey 2007/8)



Few developing countries have well-defined seed policies to guide development: in many instances private seed companies are unable to use their performance trials as part of the official variety release process, and with the financial constraints experienced by many public agencies, this retards the speedy introduction of new varieties.

State control of seed markets is often regarded as protecting farmers' interests and national economies. Results have shown, however, that free trade works to the advantage of both the farmer and the national economy.

Few countries have established accreditation to important international organizations such as the Organisation for Economic Co-operation and Development (OECD), the International Seed Testing Association (ISTA), etc., and thereby experience difficulty in accessing international markets. (Table 1 shows the position in Eastern and Southern Africa while Table 2 shows the time lag before market release of a new variety.)

Table 1 Table no.1 Status of seed control legislation in Eastern and Southern Africa DTMA Seed sector survey 2007/8

	Seed Act	Plant Variety Protection	Variety Registration	ISTA Accreditation	OECD Accreditation
Eastern Africa					
Ethiopia	No	Yes	Yes	No	No
Kenya	Yes	Yes	Yes	Yes	Yes
Tanzania	Yes	Yes	Yes	No	No
Uganda	No	No	Yes	No	No
Southern Africa					
Angola	Yes	No	Yes	No	No
Malawi	Yes	No	Yes	Yes	Yes
Mozambique	Yes	Yes	Yes	No	No
South Africa	Yes	Yes	Yes	Yes	Yes
Zambia	Yes	Yes	Yes	Yes	Yes
Zimbabwe	Yes	Yes	Yes	Yes	Yes

Table 2 Length of seed release process in selected countries

	Actual time to seed release (years)			Time from release to time significa quantities of seed is available (years)		
Country	Mean	Minimum	Maximum	Mean	Minimum	Maxim
Kenya	3.1	1.5	6.0	2.4	0.0	9.0
Malawi	3.0	2.0	7.0	1.9	0.5	3.0
Tanzania	2.2	1.0	3.0	2.0	1.0	3.5
Uganda	2.2	1.0	4.0	2.1	1.0	4.0
Zambia	2.1	1.0	3.5	2.5	2.0	3.0
Zimbabwe	2.2	1.0	3.0	2.4	1.5	4.0
South Africa	2.0	2.0	2.0	2.5	2.0	3.0

Source: DTMA Seed sector survey 2007/8

Government and Donor Mindset

As stated earlier, there is adequate germplasm and information available for growers to produce enough food for the world's population.

The mindset of many governments in developing countries is not responsive to market demands, resulting in poor exploitation of natural, human and technological resources. In spite of the crucial role agriculture plays in national economies, there is too little investment in agriculture and research in the domain is often the lowest of national priorities!

Some donor agencies are not long-term development-oriented and often do not collaborate with local authorities. Valuable funds are spent on short-term relief which adds little value to long-term sustainable development. Governments and donor agencies should therefore adopt Ms Anderson's approach and focus on educating farmers and improving their operational efficiency by making available the right tools, information, finance and markets.

Conclusion

It is gratifying that seed stakeholders have mobilized to deal with anticipated demand and challenges to plant breeding and are trying to find a global response through the exchange of ideas such as is taking place at this 2nd World Seed Conference.

Developing countries should consider a change in mindset by placing emphasis on developing agriculture and adopting current and new technologies.

The adoption of progressive seed laws and regulations with effective harmonization of the seed trade will give farmers better access to improved seeds.

Public-private partnerships are not only essential but critical for the seed sector: the Indian sub-continent and South East Asia have seen a higher growth rate in agriculture mainly because of cooperation between the public and private sectors.

Discussion

FRANÇOIS BURGAUD (GNIS, FRANCE): I totally agree with the remarks of Marcel Kanungwe about the importance of the partnership between the public and private sector and especially in developing countries. I have two remarks and questions: First, I didn't take the floor earlier but I was surprised by the figure given by Marcel Bruins that the increase of yield has been the same in developing countries as in developed countries over the last 50 years. I think it would be interesting to enter into more detail on that because at least in some developing countries, of course in sub-Saharan countries, but also in some countries in South-East Asia, it is not the situation as I know it. The second is about the fact that Marcel Kanungwe said that it would be good to have good cooperation like in India. I would be interested to know the feelings of Mrs. Barwale about the cooperation between the public and private sector in India, because I have not the same feeling on that point. And mainly I have the impression that cooperation is in reality separation and the public sector is in charge of self-pollinated crops and the private sector is in charge of hybrids and vegetables. But maybe I'm wrong. And the last thing: I think it's really a big problem because the situation today is not at all about partnership. The situation today, especially today, is really that there is not much co-operation between the public and the private sector, and I know of very few partnerships, especially in breeding.

ORLANDO DE PONTI (ISF): You asked the question to Usha Barwale. I propose as this is an important issue, participation and collaboration public-private etc, I will move it to the general discussion at the end of the session because I think it is important to give it more attention than the limited amount of time that is left now.

EFFECTIVE USE OF MODERN BIOTECHNOLOGY, MOLECULAR BREEDING AND ASSOCIATED METHODS AS BREEDING TOOLS

Mrs. USHA BARWALE ZEHR*

Biotechnology has been at play since prehistoric times. Selection for visible phenotypes that facilitated the harvest and increased productivity led to the domestication of the first crop varieties and can be considered the earliest examples of biotechnology. The utilization of plant breeding methodologies has led to the development of improved varieties. The high yielding varieties of the green revolution transformed agriculture in many developing countries, providing an opportunity for farmers to improve crop harvests and livelihoods. During this time, some hybrids were also being cultivated around the world and more research started on a whole range of crops to exploit hybrid vigor. In general, productivity was improved by over 10 per cent in most crops and by much more in others.

Some of the most significant crops in the world, rice and wheat, being self-pollinated species could not be hybridized on a commercial scale. Research in these crops has also continued and today hybrid rice and hybrid wheat are being cultivated in many countries, keeping pace with production needs. As hybrids developed, critical factors relating to grain quality had to be met for the crop to be acceptable to consumers. The area under hybrid wheat and hybrid rice continues to grow. The utilization of genetic diversity has made this possible, and with the use of male sterile female parents, hybrid seed production became feasible. While the current hybridization systems in these two crops are making progress, continued effort in research is needed to find alternate male sterility sources as well as further diversification of the existing germplasm.

Self-pollinated species such as chickpea, pigeon pea, peanut and others have not benefited from some of these technological advances due to their inability to produce commercially viable hybrids.

The 1980s saw the modern plant biotechnology era begin with the first transgenic plants being produced in 1983, using Agrobacterium-mediated transformation. This was soon followed by the use of molecular marker systems for crop plants by creating high-resolution genetic maps. These two technologies presented, as never before, opportunities to understand and learn how genes can be transferred across species' barriers and how they function. Use of molecular markers was incorporated more and more in traditional breeding programs particularly in the private sector.

Molecular breeding

Technological advances in molecular breeding have been truly spectacular and the reason for this is in part due to the benefits that the technology provides. Molecular breeding exploits useful genetic diversity for crop improvement, offers greater precision and the efficiency of selection is enhanced. All of these factors are allowing for greater gains year-on-year which is reducing the time it takes to develop a new variety or hybrid.

Molecular breeding started with marker systems like the RFLPs where a limited number of markers could be tracked and the time taken was longer than the present day molecular systems which are moving more and more to SNP databases, allowing for whole genome selection, backcrossing programs, MAS and genetic analysis in general. The molecular marker systems are also critical in IP-related matters. Having a ready fingerprint of a proprietary line can be key in ensuring that the breeder's material is protected from illegal use.

* Director of Research, Mahyco, India

Molecular breeding can be most effective when good phenotyping is also available for the material. Combining the phenotype and the genotype serves to associate certain markers with a phenotype validating their use. Not all markers can be linked to phenotypes but they can still be used productively. In the case of rice for instance, it is possible to integrate all relevant bacterial leaf blight tolerance Xa genes into commercial parents ensuring that the hybrid is tolerant to this common disease. The markers are well defined and most products are moving towards having at least three Xa genes for durable tolerance. Similarly, a more challenging problem in rice is the brown plant hopper. Good phenotyping methods are available for screening the germplasm and also molecular markers have been identified which provide varying levels of tolerance.

Selecting the best germplasm based on the phenotype screening methods and then applying the knowledge of available molecular markers strengthens the probability of tolerance in the ultimate product. Also this overcomes some of the variations one may see in phenotype screening due to environmental factors. In the case of rice, there are many advantages in that the entire genome has been sequenced and a lot of information is available. The challenge for us is to translate this information into a usable format and to be able to address challenges like drought, salinity and yield per se. When looking at drought, for durable tolerance there is a need to address all the stages of drought the crop may be subject to such as seedling stage drought, pre- and post-flowering drought. Also, the need to find tolerant germplasm and the ability to do phenotyping in combination with the power of molecular breeding may ultimately give us plants which can tolerate drought stress better.

All of these molecular advances are allowing the plant breeder to accumulate more and more of the favorable alleles in the lines being developed, thus improving the genetic potential of the crop. All of these tools are available and ready to go. In some crops like maize, soybean, rice, tomato, to name a few, the use is extensive and growing. Much more work is needed in other crops and it must be applied more widely so more and more breeders can benefit from these technologies, ultimately leading to better product for farmers.

As molecular technologies advance, we continue to gain a better understanding of critical functions which lead, for example, to heterosis. Looking at expression profiles of parents and hybrids may shed some light on what valuable contributions are made by which line or what stages of plant growth have the greatest impact on hybrid vigor. This kind of understanding will allow breeders to become more precise on what elements to combine in the lines being developed.

Transgenic crops

This is another example of how biotechnology has impacted on agriculture in the last decade. The first question often asked is why there is a need for transgenic crops. Generally when there are no known sources of tolerance and the conventional approaches to date have not been successful, transgenic crops can provide an alternative approach to address the challenge faced by a certain crop. The first generation traits which have been commercialized have addressed the following;

- Insect-tolerant crops
- Herbicide-tolerant crops
- Disease-resistant crops

As technological advances are allowing us to address more complex traits, the transgenic crops in the product pipeline are addressing the following;

- Drought
- Salinity
- Fertilizer use
- Yield per se

Transgenic crops have changed how a crop is seen; taking the example of cotton in India, this particular sector has changed at farm and farmer levels, and has increased trade and foreign exchange earnings. At the farm level, productivity has gone up, net returns have increased and 50 per cent fewer pesticides have been used. At the farmer level, labor costs have gone down, exposure to pesticides has been reduced, making an overall positive impact on health. India has moved up to being the second largest producer of cotton in the world with the introduction of one single technology and changed to being a net exporter from being a net importer. The positive environmental impacts are also well documented. Similarly many examples are now available which address salinity, virus and insect problems and the list is endless. The future looks bright.

Conclusion

With the examples discussed here, it is clear that biotechnology is providing unprecedented options for enhancing plant breeding. Much progress has been made with some crops. This needs to be more rapidly adopted and implemented where it is not being used today and more work is needed on crops where the data available is limited. The technology itself holds enormous potential. Molecular breeding and transgenic crops will continue to play a key role in improving productivity in a sustainable manner, as has been seen in the last 15 years. The biotechnology revolution is underway, use of molecular tools and transgenic crops will allow us to meet our food needs in a sustained manner with limited availability of resources.

Discussion

JEAN PIERRE POSA (CHILEAN SEED ASSOCIATION ANPROS AND SEED ASSOCIATION OF THE AMERICAS SAA): Through these nice presentations we have seen that traditional breeding techniques and modern breeding techniques are really advancing breeding in the world. I do not really have a question, but my worry is that some of our companies and breeders are spending a lot of time dealing with basically regulatory issues, IP issues, probably more than they're worrying about traditional breeding or modern breeding techniques. Maybe that's a subject that somehow can be touched upon because there are still many countries where our breeders are really fighting the systems and basically becoming what I would call lawyers or agricultural bureaucrats, which makes breeding very difficult.

ORLANDO DE PONTI (ISF): I consider this just as a comment, and it's quite possible that you or somebody else would like to bring this back in the general discussion.

FRANÇOIS BURGAUD (GNIS, FRANCE): I would like to know if the breeding tools explained and used are patented in India and, if so, what is the cost for Mahyco to use these patented tools?

USHA BARWALE ZEHR (MAHYCO, INDIA): Indian patent law does provide for the ability to protect DNA at different levels, but it does not allow for protection of varieties. So at this moment as companies are developing new technologies, we are seeking to have greater clarity on what is protectable and what is not. We take account of the cost of the use of molecular markers as of any other cost in plant breeding. In some cases it is high, but only if the value that we get from it is also high are we eager to use it, because it would be under license if it does not belong to us. So there is a cost associated with it but this is relative to the benefit that we get.

THE OPPORTUNITIES PRESENTED BY MODERN BIOTECHNOLOGY TO ENHANCE PLANT BREEDING: WHAT'S IN THE PIPELINE? WHAT WILL DEFINE THE FUTURE?

Dr. WILLIAM S. NIEBUR*

Crop Genetics Research & Development

Plant breeders face a number of challenges to increase food supply and productivity compounded by a growing global population, a limited amount of arable land and numerous other issues around the world. However, this is an exciting time. Never before have we seen the convergence of so many new technologies that will allow us to develop more productive, more efficient crops more quickly than ever before. Biotech tools are allowing us to expand plant breeding programs, accelerate the rate of genetic gain, fully exploit native genes and bring new attributes to crop species.

In several crops and geographies, yields have increased significantly over recent decades. For example, corn productivity in the US has increased dramatically through a combination of new technologies and improved management practices. Those productivity increases, however, have not been seen on a global basis or across all crops.

Biotechnology is a critical tool to enhance plant breeding and meet the Pioneer goal of increasing corn and soybean yields by 40 per cent by the year 2018, which would effectively double the rate of genetic gain we've seen over the last decade.

Tools of Modern Plant Breeding

There are a number of tools and technologies, which, combined with our knowledge of crops and elite germplasm base, create two pathways to product development (see Fig.). These pathways are linked through our strong enabling technologies which allow us to move at will between them.

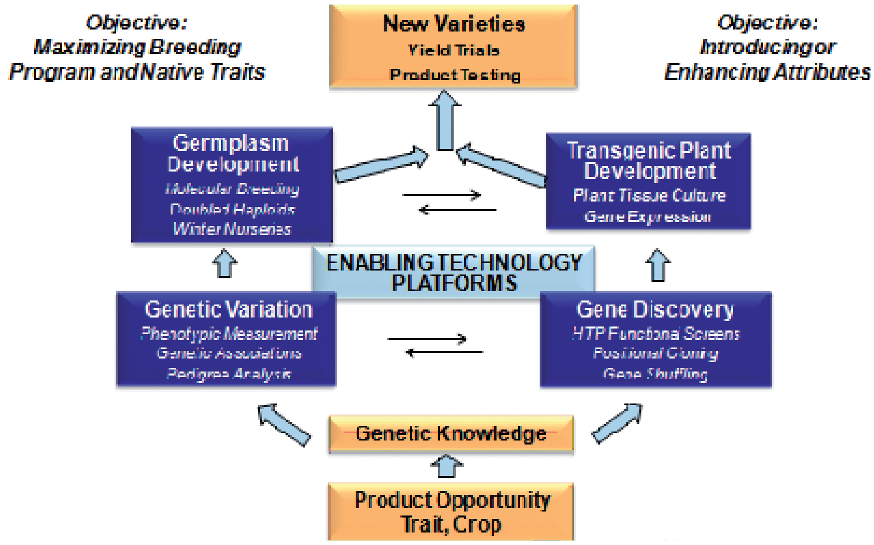
Both pathways are deeply grounded in genetic approaches, in which we assay for a trait and then discover the underlying genes. The left side shows the discovery of native traits, or the characterization and molecular isolation of genes that reside in the crop itself, although sometimes in wild relatives or in low yielding varieties. Delineation of these genes using mapping/molecular markers identifies genes that are necessary and sufficient for a trait. The right side shows discovery of transgenic traits, where we want to change the expression levels, location or timing of a gene, to add more power to a trait, or to use a gene from a different species, whether another plant or a microbe. This is also the pathway where we can apply genetic shuffling to dramatically alter and enhance the properties conferred by a gene.

Today, increasingly, both paths must come together to complete the package before a new product is developed. For example, molecular markers are used to identify and clone a native gene of interest, and then develop either a non-transgenic or transgenic product depending upon whether changes in gene regulation are or are not needed.

Mining existing germplasm for novel or rare alleles includes looking for opportunities to more fully exploit native variation, to shorten breeding cycles, and to get more genetic gain from each cycle of a breeding program through the precision of molecular breeding.

* DuPont Vice President, Crop Genetics Research & Development, Pioneer Hi Bred International, Inc., A DuPont Company, United States of America

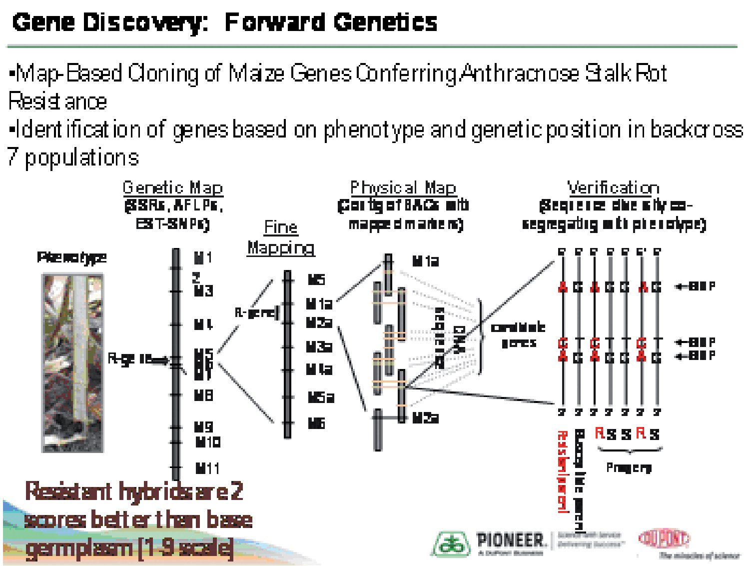
Fig 1 The tools of modern plant breeding



Our knowledge of the corn genome has increased exponentially with the advent of a number of specific technologies that allow quicker, more efficient analysis of the plant, including:

- Doubled haploids and molecular markers which allow the identification and characterization of more native genes than ever before.
- Laser-assisted seed selection which provides the ability to analyze an individual kernel to determine if it has the desired properties. Decisions can be made immediately without planting in the field and waiting for the next growing season. It is a fully automated seed sampling process for increased breeding accuracy and efficiency.
- At Pioneer, FAST (Functional Analysis System for Traits) corn is another example of using leading-edge technology to reduce the time it takes to identify and test potential leads for new traits. FAST corn is used to more quickly test agronomic expression of plant characteristics, such as water use efficiency or nitrogen use efficiency.

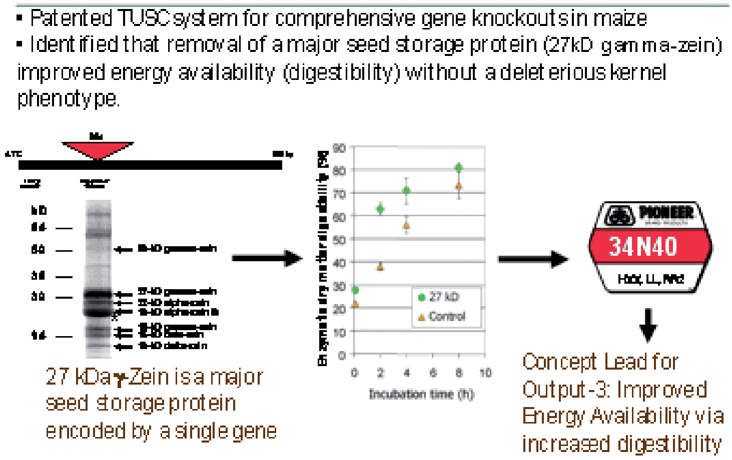
Fig 2 Gene discovery: forward genetics



Both forward genetics (see Fig. above) and reverse genetics (see Fig. below) are being used to introduce new attributes or enhance existing traits in the plant. Forward genetics seek to find the genetic basis of a phenotype or trait, then clone the sequences underlying a particular mutant phenotype. Reverse genetics seek to find the possible phenotypes that may derive from a specific genetic sequence obtained by DNA sequencing.

Native traits play a key role in enhancing yield by giving the plants the protection they need from diseases and pests, such as brittle snap, fungal diseases, aphids and nematode, and native traits can enhance a plant's tolerance for various stressors, such as cold and drought. Native genes have also been employed to improve nitrogen utilization and enhance grain quality.

Fig. 3 Trait discovery: Reverse genetics



Modern plant breeding is moving quickly away from the paradigm of native versus transgenic traits to integrating transgenic and native genetic diversity with genetic knowledge. Using all of these tools, new products can be developed with the strengths of both.

Finally, the sun never sets on plant breeding today. Vast networks of seed companies, governments, universities and other research centers are employing modern breeding and biotechnology to accelerate plant improvement on a multitude of crops around the globe.

Enhancing Productivity with New Products and Traits

The goal of all these technologies is simple – developing new hybrids or varieties that bring additional value to the world's farmers. By combining native and transgenic approaches, researchers around the world are working to develop solutions to growers' most critical agronomic challenges and unmet needs.

The following pipeline technologies represent several game-changing opportunities for yield gains by helping plants overcome stressors in their environment, such as drought. Others are much further out on the development timeline, but represent exciting opportunities that could change the way we approach crop production:

- Insect protection on more acres
- Multiple modes of glyphosate tolerance
- Pollen fertility control, hybrid production
- Improved fuel, food and feed value
- Drought tolerance – native and transgenic
- Carbon sequestration
- Nutrient use efficiency
- Disease resistance
- Transgenic yield enhancement
- Salinity tolerance
- Plant density, plant architecture
- Cold and frost tolerance

Finally, the development of these technologies is also dependent on continuing to break down barriers on a global basis, including addressing the regulatory environment and IP issues, promoting biotechnology acceptance and responding to the need for increased science and technological education and training.

Discussion

ORLANDO DE PONTI (ISF): You mentioned a lot of important developments, complex traits such as drought, yield etc. Listening to scientists and breeders in a variety of conferences I feel there is always quite an emphasis on the potential of molecular biology, molecular genetics. Do you feel that you can develop those complex traits without massive investment in disciplines like plant physiology, etc. and what is your opinion on how to get these complex traits to a higher potential?

BILL NIEBUR (PIONEER, US): We are hiring today disciplines and domains that we never imagined we would hire into our plant breeding community: statistical modelers, mathematicians, physicists in some cases and even musicians. We're hiring individuals with very diverse backgrounds who understand complex systems and what you've described in agronomic traits are truly complex systems. A single point intervention creates a perturbation in a very complex biological system that has all kinds of compensatory mechanisms. And what we're really challenged to do is to bring the physiology, the cell biology, the metabolic profiling and the biochemistry back into our plant breeding programs to be able to understand the variability that we're able to create in controlled environments via genetic intervention. And so, Mr. Chairman, as you've suggested, your average plant breeding company today looks very, very multidisciplinary, very, very cross-functional and what we're finding is that many of those skills are not resident in our organization but we build those relationships through collaborations with universities, regional agricultural institutions, as well as global private sector partners.

IR HINDARWATI (CENTER FOR PLANT VARIETY PROTECTION, INDONESIA): Do you have any program for plant genetic resource conservation? In my opinion, it should be divided equally. I believe you are initially exploring the genetics from the land and then you put in some technology to make a new variety. Do you have any program for equal treatment of the genetic resources and the exploration of genetics?

BILL NIEBUR (PIONEER, US): An excellent foundational question for every plant breeder. We know that the basis for long term gain in selection programs is dependent upon having access to germplasm diversity. We have invested heavily in re-sequencing nearly 20,000 genes across 1,500 different accessions today to be able to understand allelic variation, allelic number, gene forms in the foundational populations from teosinte for example and maize through all of the open-pollinated varieties and to what were the hybrids of the early parts of the last century. We're extensively looking at that as well in soybean, millet, sunflower, cotton and canola. We absolutely believe that the re-sequencing work that we're doing today, enables association genetics in these species and allows us to begin to unravel the genetic basis for most of the important traits that we're trying to improve; it's interesting, Arabidopsis becomes a very fast form of canola. I mean it's simply a plant that we can use to do gene discovery in one tenth of the time that it would take us to do that same gene discovery in a canola plant or an oilseed rape plant or a mustard plant. So, right to your point, we have mass collections of germplasm. I showed the molecular profiling that we're doing in maize. We're doing that same sort of profiling in multiple species. Absolutely, fundamentally important.

ZEWDIE BISHAW (ICARDA, SYRIA): My question is, as you know biotechnology is quite high cost and it requires quite a huge investment. If you look into the public breeding particularly in the developing countries, access to this type of technology or researching part of the technologies is quite expensive. How do you see the role of the multinational companies in providing this type of technology in some form of partnership, particularly in developing countries?

BILL NIEBUR (PIONEER, US): Great question, and really comes to the fundamental foundation of how we collectively advance rather than individually advance. I can always tell a plant breeder by their level of humility, and anyone who has been a plant breeder who finds himself humbled by the environment and by the challenges that we face. The investment that you talk about keeps us all very sober about what the possibilities are. The investments are huge. The requirements are huge. What we've chosen to do, I believe increasingly is, as an industry, play a role via the foundations, via the CG system, where I have the opportunity to participate in the private sector committee. We believe that the opportunity really comes through partnerships. In the last five years we have educated 10 African scientists on-molecular markers and transgenic technology and they are currently working in Africa but they did their studies and they did a one or two year sabbatical in our laboratories educating them on the modern technologies and then partnering with them in research programs to give them access. So what we're doing today is why we don't believe that every developing country in the world needs to develop the molecular marker capabilities; we have those capabilities and partners, and we can take the DNA. DNA is DNA. Be it from cowpea, chickpea, cassava or maize. And we can run it through our systems and I think with the opportunity of going forward to identify the problem, develop a project to address the problem, and then form a collaborative relationship to be able to make those enhancements, building infrastructure, creating intellectual capital in the environment in which we're working and driving genetic gain in that crop. And again, trying not to compete with one another but to solve the problem, to collaborate.

BUILDING CAPACITY FOR PLANT BREEDING IN DEVELOPING COUNTRIES

MR. ELCIO P. GUIMARÃES*

Introduction

Since the rediscovery of Mendel's laws early in the 20th century, the improved varieties planted by farmers worldwide have increasingly been developed by well-trained plant breeders, in contrast to farmer-developed varieties of previous eras. Breeders use knowledge about the crops, plant genetic resources conserved in gene banks, scientific breeding methodologies and tools, and effective seed delivery systems. Any disconnection or broken linkages in this chain result in lack of improved materials available to farmers.

Access to plant genetic resources, according to the experience reported by many countries,[1] became more difficult in the last decade. In general, plant breeding programs in developing countries worldwide have lessened their capacity to develop improved varieties, and seed delivery systems have deteriorated. In addition, soaring food prices up to 2008 and the resulting international economic situation have contributed to diminished potential to invest in the different elements of this technological chain. Increases in productivity and production remain well below their potential.

While recognizing the importance of all three major elements in this chain (plant genetic resources, breeding and seeds), this paper will focus on the plant breeding component. It will provide information on the worldwide assessment carried out by FAO to understand the plant-breeding capacity at national, regional and global levels; describe the development and functions of the Global Partnership Initiative for Plant Breeding Capacity Building (GIPB); and suggest how national capacity can be improved, including seed delivery systems. Also without discounting the great contribution of the private sector and the influence of the UPOV Convention in increased varietal development and dissemination activities, the aim of this paper is to focus on the activities of the public sector in this area.

Assessing the National Plant Breeding Capacity

Scientists working with plant genetic resources frequently comment that "plant breeding capacity worldwide is decreasing; the average age of the breeders is increasing as there are fewer young scientists being attracted to the field; biotechnology tools are becoming more easily available and are enhancing plant breeding; and the seed systems are being continuously weakened in many countries". In 2003, an article published in Nature (Knight, 2003) called the world's attention to this problem. In order to better understand the above statements and to produce data to substantiate or negate them, in 2002, FAO, and a large number of partners, including the CGIAR centers, started assessing the national plant breeding and related biotechnology capacity worldwide.

The national capacity assessment was made based on a questionnaire prepared to gather data on the following:

- the number of plant breeders[2] working in public and private sectors;
- the age of the plant breeders;
- the number of plant biotechnologists applying the tools on issues related to plant breeding in public and private sectors;
- the crops and/or crop groups under improvement;

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* GIPB team members at FAO, in collaboration with Mr. Clair Hershey, Mr. Eric Kueneman and Mrs. Michela Paganin, Italy.

[1] Country reports prepared by 109 countries worldwide on the "State of Plant Genetic Resources for Food and Agriculture" as contribution to the "second State of the World's Plant Genetic Resources for Food and Agriculture report" (SoW-2) to be presented to the Commission on Plant Genetic Resources for Food and Agriculture on October 19-23, 2009.

- the biotechnology tools used by the plant biotechnologists;
- the number of varieties released.

National consultants (generally plant breeders with broad experience in the target countries) carried out the survey. The information was gathered taking a five-year interval starting in 1985 and ending in the year of the survey. This series allows for drawing a trend curve for each set of data. To date more than 80 countries have replied to the questionnaire.

Based on survey data from Africa, Guimarães et al. (2006b) found that the number of plant breeders have increased in some countries since 1985, but the current numbers in many countries are still below the critical level that would allow for achieving the proposed national program's goals. The situation in Central Asia contrasts with that of Africa: even though similar declines were reported in many countries in the region, the number of breeders is still high enough to deliver improved varieties required by farmers (Guimarães et al., 2006a). In the Near East and North African regions the assessment suggested that the number of breeders is below the critical level (Guimarães et al., 2007). Nonetheless, in all three regions financial support for crop improvement declined significantly, impeding efficient crop improvement programs.

Frey (1996) surveyed the US plant scientists in the mid-1990s and found that crop improvement was largely a private venture, with twice as many breeders in the commercial sector as in universities and government agencies combined. In Brazil, Guimarães (2008) identified 467 plant breeders of which 35 were in the private sector and 214 worked at the Brazilian Agriculture Research Corporation (Embrapa), a public institution.

To house the results of the assessment carried out by FAO, GIPB created a database called "Plant Breeding and Related Biotechnology Capacity Assessment" (PBBC), which can be found at http://km.fao.org/gipb/pbbc. In addition to data on plant breeding capacity on PBBC, all reports prepared by the consultants are available, along with country briefs summarizing the key findings and suggesting actions to strengthen the national capacity.

Global Partnership Initiative for Plant Breeding Capacity Building

The downward trend in national capacities to utilize plant genetic resources for food and agriculture underscored the need for an international initiative in building plant breeding capacity. The results of the assessment of plant breeding and related biotechnology capacity worldwide provided strong indications that capacity building in plant breeding and related biotechnology is the key to strengthening the possibility for developing countries to promote and benefit from sustainable agricultural development. The limitations in trained scientific and technical personnel and institutional weaknesses within the plant breeding sector and in its links with genetic resources and seed delivery systems are key challenges that prevent the potential contribution of plant breeding to sustainable development to materialize more widely.

The GIPB was launched in Madrid in June 2006 at the time of the First Governing Body Meeting of the International Treaty on Plant Genetic Resources for Food and Agriculture and was proposed to enhance professional and institutional plant breeding capacity in support of crop production intensification, food security and sustainable development.

The GIPB was proposed as a partnership of public and private sector parties from both North and South, working in concert to enhance the capacity of developing countries to improve their agricultural productivity through sustainable use of plant genetic resources for food and agriculture.
The mission, vision and five longer-term objectives of the GIPB were defined through a consultative process aiming at the integrated enhancement of national plant breeding capacity building strategies for sustainable crop intensification and production system development. The GIPB (2008) Business Plan defines the mission as enhancing the capacity of developing countries to improve crops for food security and sustainable development through better plant breeding and delivery systems. The vision is described as the improvement in crop performance and food security based on the establishment of enhanced sustainable national plant breeding capacity. The five objectives are:

- Objective 1. Support policy development on plant breeding and associated scientific capacity building strategies, to help allocate resources to strengthen and sustain developing countries' capacity to use plant genetic resources for food and agriculture.
- Objective 2. Support education and training in plant breeding and related scientific capacities relevant to utilization of plant genetic resources.
- Objective 3. Facilitate access to technologies in the form of tools, methodologies, know-how and facilities for finding genetic solutions to crop constraints.
- Objective 4. Facilitate exchange of plant genetic resources, from public and private breeding programs, that can enhance the genetic and adaptability base of improved cultivars and production systems in developing countries.
- Objective 5. Share information, focused on plant breeding capacity building, to deliver newly available knowledge to national policy makers and breeders in developing country programs.

Lessons from the Regional Consultations

The GIPB is carrying out a second level of analysis beyond the country studies, to look at capacity at the regional level and to understand how capacity building might be made more effective and efficient when countries within a region collaborate. At the time of writing, these studies are at different levels of completion.

South and Southeast Asia.

Based on a review of the country surveys, as well as an online consultation among breeders in the region, five recommendations were elaborated:

1 To focus on training for efficient integration of molecular breeding tools into plant breeding research.
2 To train breeders in analysis techniques to set the right priorities for breeding in both the short-term and long-term.
3 To facilitate cooperation among institutes within a country and internationally, e.g. sharing of laboratories for biotechnology.
4 To develop a budgeting approach that allows for long-term investment rather than an annual budget cycle.
5 To set up a system for rewarding research stations for doing a good job providing the best planting materials to farmers.

Sub-Saharan Africa.

In most countries, breeding priorities have historically been skewed toward species of export value. As a result, priority is given to developing varieties, in the shortest time possible, that meet foreign market standards. In countries that have crop-specific institutes (e.g. Ethiopia, Ghana and Malawi) a large number of crops or crop groups tend to benefit from breeding. On the other hand, where plant breeding research is relatively new, there are only a few crops that benefit from breeding. The CGIAR centers constitute a major source of germplasm used in breeding programs in all the surveyed countries, particularly for crops within their respective mandates. While the number of breeders has increased somewhat throughout the region over the past 20 years, as well as their level of qualifications, there remains a major concern about the high staff turnover rate in most national plant breeding programs, mainly due to lack of incentives to retain the most qualified and competent staff. The lack of good financial records in many countries makes it difficult to make a good assessment of the national funding situation of agricultural research, as well as that from external sources.

Western Asia and North Africa.

The overall trend of declining plant breeding capacity appears to be clear from the survey results. Stagnant or reduced budgets and fewer released varieties have been recorded in the last 20 years. One of the principal factors underlying the problem of reduced funding faced by the public sector is lack of awareness among policy decision-makers on the impact of plant breeding on national development.

The public and private sectors often operate largely independently. Countries of the region need to promote training on both conventional and biotechnological tools, helping prepare project funding and facilitating germplasm exchange. However, this support will only be of value if these scientists co-ordinate action among themselves and with other disciplines in both the public and private sectors.

Latin America and the Caribbean. There is a wide diversity of situations in this hemisphere with regard to the capacity of plant breeding programs, much of it related to the size of the country, and, consequently, the size of the agricultural sector and its ability to invest in plant breeding and biotechnology. The under-investment in plant breeding and associated technologies is evident in both human resources and physical resources, and it cuts across both public and private sectors. A main challenge for motivating the participation of the private sector is the relatively small size of the market. In view of this, the two-tier debate is whether each country should have its own seed market or be involved in regional or international seed markets. In taking these decisions, these countries need to ask themselves how much yield potential they are giving up by not being fully able to breed for local conditions or access improved varieties suited to their agro-ecological conditions. A further argument relates to the cost-benefit rationale as well as profitability of home-grown seed in contrast to imported seed.

Factors Limiting Success

After all the resources are assessed, and considered in combination, it is possible to better determine the factors that limit success of breeding in a program. At this stage, the surveys enter into a more subjective area, as compared to the hard figures on institutional and personnel resources. In the 15 to 20-year period of the survey coverage, there is relatively high consistency in the important limitations, especially those at the top of the list. Table 1 summarizes the limitations perceived by scientists and research administrators on a regional and global basis. Interestingly, in spite of the decline in resources available for plant breeders, the lack of financial resources to carry out field and laboratory experiments ranked only seventh in importance as a constraint limiting success in plant breeding programs. Nonetheless, this lack of financial resources would also be reflected in other areas of capacity. From the survey, five limiting factors stand out at the global level (in order of importance):

- Inadequate experimental field conditions
- Inadequate number of breeders for each crop
- Inadequate access to recent literature
- Inadequate knowledge level of the general plant breeding strategies
- Limited access to international genetic resources

While there is general consistency among regions, there are also a few marked regional differences. For example, "inadequate number of breeders" is ranked first in Asia, but only at a medium level of importance in the Americas and in Africa. "Inadequate knowledge level of general plant breeding strategies" is ranked first in Africa, but only given a medium level of importance in Asia and the Americas. "Limited access to international genetic resources" is a very important constraint in Africa and the Americas, but of only medium importance in Asia.

The implications for these results are that capacity building should be defined and carried out in a systematic manner that takes into account both the unique needs of a country or region, but at the same time should make use of the efficiencies that can be gained by the common needs across countries and regions. Of the top five priorities at the global level, it appears that perhaps only "access to international genetic resources" may show a relatively low importance in Asia, while the other priorities can be understood to be of at least moderately high importance across developing countries.

These top-ranked priorities include all the elements of the GIPB priorities and goals relating to policy, education and training, access to technology, access to genetic resources and sharing of knowledge and information. They indicate that in order to have optimal impact on capacity for crop improvement, a comprehensive approach is necessary.

Even though lack of mechanisms to stimulate private sector investments was not listed among the top priorities, countries in all regions recognized the need to have adequate national legislation to allow private sector investment in plant breeding. Some of them stated that public/private partnership is necessary to motivate efforts on crops that may not be as economically attractive as the major food crops.

Strategies to Build National Capacity in Developing Countries

In order to establish an effective national strategy to use plant genetic resources in developing countries, it is key to stimulate traditional plant breeding along with the application of biotechnology tools and to ensure that effective seed delivery systems are in place. There is no single strategy to achieve this, but it is relevant to consider the following general recommendations:

- To elaborate and maintain a pragmatic national strategy for food production, taking into account internal and external markets.
- To develop public awareness about the importance of plant genetic resources and their use and impact on crops and food production, including the seed delivery systems.
- To establish a mechanism to ensure harmony among the goals of plant breeding research and the application of biotechnology tools.
- To have in place mechanisms that ensure strong linkages among plant genetic resources, plant breeding and seed delivery systems.
- To have in place instruments to stimulate private sector investment and public/private partnerships.

Policy makers responsible for providing support to national programs working with crop improvement must be clear in their minds that an effective strategy requires investment from governments. Success entails long-term financial commitment because breeding a new variety and delivering it to farmers often takes more than 10 years.

Conclusions

Capacities in plant breeding, including both conventional and modern technologies, in most developing countries are neither sufficient nor properly integrated to fully capture the benefits of the plant genetic resources that are conserved. The lack of long-term support for national breeding strategies and programs leads to a lack of effective access to germplasm and technologies, especially biotechnology. In general, biotechnology work is done at universities without links with plant breeding programs. The limitations in trained personnel, institutional weaknesses and inefficiencies, both within the plant breeding sector and in its links with seed systems, are key elements that prevent the potential contribution of plant breeding to food security and for sustainable development to materialize. Mechanisms to promote public and private partnerships are also crucial to the success of national strategies to improve crops. This leads to under-developed seed systems and to poor transfer of improved germplasm to rural producers.

Raising the capacity of plant breeding at national and regional levels requires the training of more plant breeders and the development of an integrated set of capabilities and support systems to build and sustain effective national and regional plant breeding capacities. At the same time, dealing with the resulting increase in crop productivity and in supply, processing and distribution of agricultural commodities can make an important contribution to further improving food and nutrition security and to the livelihoods of small scale producers, providing a source of increased production diversification, income and employment opportunity in the entire food chain. These facts need to be taken into account by governments and development organizations in formulating development strategies

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Table 1 Limiting Factors for Success in Plant Breeding Programs by Region, 2001/2005, as registered in Survey Results

	Ranking by region [1]															
Limiting factors	Caribbean	Central America	South America	West Africa	Eastern Africa	Middle Africa	Northern Africa	Central Asia	SE Asia	S Asia	West Asia	Overall Average	Americas rank	Africa rank	Asia rank	Overall rank
Inadequate experimental fields conditions	0	5	5	5	0	0	3	4	4	4	4	3,1	1	3	2	1
Inadequate number of breeders for each crop	5	0	0	1	1	1	4	5	5	5	5	2,9	4	5	1	2
Inadequate access to recent literature	0	4	4	0	5	3	0	3	3	3	3	2,5	3	4	3	3
Inadequate knowledge level of the general plant breeding strategies	0	3	0	4	4	5	2	0	2	2	2	2,2	5	1	4	4
Limited access to international genetic resources	4	2	3	3	3	0	5	0	1	0	0	1,9	2	2	7	5
Lack of knowledge about the use of molecular techniques to support plant breeding programs	2	0	0	0	0	4	0	1	0	0	1	0,7	8	6	6	6
Lack of knowledge about participatory plant breeding techniques	0	1	2	2	0	0	0	2	0	1	0	0,7	6	8	5	7
Lack of financial resources to carry out field and laboratory experiments	0	0	0	0	2	2	0	0	0	0	0	0,4	11	7	8	8
Limited access to national public and/or private genetic resources	3	0	0	0	0	0	0	0	0	0	0	0,3	7	10	9	9
Inadequate availability of laboratory infrastructure to carry out experiments using advanced plant breeding techniques	1	0	0	0	0	0	1	0	0	0	0	0,2	9	9	10	10
Lack of support from the international community, including organizations like Centres of CGIAR system, FAO, etc.	0	0	1	0	0	0	0	0	0	0	0	0,1	10	11	11	11

[1] Top five factors, by region (5=most important; non-ranked constraints assigned value of zero)
Source: *http://km.fao.org/gipb/pbbc*.

References

Frey, K.J. National Plant Breeding Study-I. Human and Financial Resources devoted to Plant Breeding Research and Development in the United States in 1994. Special Report 98. Iowa State University, Iowa Agriculture and Home Economics Experimental Station. 45p.

GIPB 2008. Business Plan 2009-2013. 60p, 1996.

Guimarães, E.P. Rice breeding. In; M.J. Carena (ed) *Handbook of Plant Breeding: Cereals*. pp.99-126, 2008.

Guimarães, E.P., Kueneman, E. and Paganini, M. Assessment of Plant Breeding and Associated Biotechnology Capacity in the NENA Countries. In: M. Baum and K. Ghosh (eds) *Harnessing Biotechnology and Genetic Engineering for Agricultural Development in the Near East and North Africa*. pp.56-63, 2007.

Guimarães, E.P., Bedoshvilli, D., Morgounov, A., Baboev, S., Iskakov, A., Muminjanov, H., Kueneman, E. and Paganini, M. Plant Breeding and Related Biotechnology Competence in Central Asia and Recommendations to Strengthen Regional Capacity. *Agromeridian Theoretical and Applied Agricultural Research Journal* 2(3):137-143, 2006a.

Guimarães, E.P., Kueneman, E. and Carena, M. Assessment of National Plant Breeding and Biotechnology Capacity in Africa and Recommendations for Future Capacity Building. *HortScience* 41(1):50-52, 2006b.

Knight, J. Crop Improvement: A Dying Breed. *Nature* 421:568-570, 2003.

Discussion

ZHEN LIU (WAGENINGEN UNIVERSITY, THE NETHERLANDS): You have mentioned so many times the public private partnership. Can you share some good stories to stimulate public private partnerships with us?

ELCIO GUIMARAES (FAO): There are many stories that would tell of how a good relationship between the public and private sector is important. With this initiative, in the GIPB, we do have on our site some examples of how the public and private partnership is taken on board by some countries and how it is producing results, so I don't want to pinpoint any specific example here, but there are many in different countries with different crops where it has shown that linkage and produced good results. The important point here is to understand that both have to benefit. We don't want to go into a partnership where one will take advantage of the other or vice versa. We have to understand the word "partnership". It requires benefits for both sides. And this is what we have been documenting on our GIPB website. If you go into the site that I have just mentioned, you will find some of the examples.

ADELAIDA HARRIES (IOWA STATE UNIVERSITY, US): I want to know if in your survey you have had any answer from the public breeding sector that one mechanism to promote public breeding and also private partnership is establishing the IP system in developing countries.

ELCIO GUIMARAES (FAO): Yes, again it's the same question. There are several examples where you find this type of partnership. And IP is not a limitation for a partnership contract. It's a stimulus for a partnership. It depends how you deal with IP rights in order to provide a benefit for both cases. I don't see any limitation in having IP issues considered when you deal with the public and private partnership. I'm from Brazil and in Brazil, Embrapa has several examples of partnerships made with multinational companies where genes from the companies are being used by the public sector in their breeding programs and IP issues are considered to be no problem at all. So again, there are many examples in this case and I don't see it as a limitation for stimulating partnership contracts. It should be a mechanism for stimulating partnerships.

CHRISTOPH HERRLINGER (GERMAN PLANT BREEDERS ASSOCIATION BDP): The issue of capacity building is an integral part of the International Treaty on Plant Genetic Resources for Food and Agriculture and I would like to know a little bit more or to learn a little bit about the role the International Treaty has played in improving this situation and what can still be done.

ELCIO GUIMARAES (FAO): As you know the Treaty is a new instrument and is being seen right now from the beginning of the implementation of the Treaty. Art. 14 of the Treaty deals with the Global Plan of Action and there are five major priority areas in the Global Plan of Action dealing with capacity building, so I see in the near future the International Treaty as a very important instrument to contribute to strengthening national capacity. Right now as I have said is just the beginning of that process and I don't think that it is time for us to evaluate whether it's producing results or not. But there is no doubt that it is an instrument that contributes strongly, and is strengthening capacity in all different areas, not only in plant breeding, but also in conservation and also related to seed delivery systems.

FRANÇOIS BURGAUD (GNIS, FRANCE): I think that we agree about the basic proposal in the last report. But we can't agree with the conclusions because when you say that there is a lack of mechanisms to promote public and private partnership it is not true. The truth is that there are a lot of mechanisms to avoid partnerships between the public and private sector. And my problem is I don't see how the FAO, which hasn't succeeded in improving the seed sectors and plant breeding in the last 40 years, would have a new chance. Bernard Le Buanec said that we have to take account of a new paradigm: I want to know what the new paradigm in FAO is that will change the situation. And I just give a few examples: FAO has implemented a lot of projects in seeds following the G8 and G20 about the food crisis. A lot of these projects in Africa were implemented without any consultation of the private seed sector of the countries which are concerned by these projects. These projects were financed by the

European Union. No discussion at all existed between the European Union, the Commission and the European seed sector about these projects. So it was decided some months ago, some weeks ago, maybe yesterday and there was no change in the policy on that. So I would really like to know what you are thinking of to implement, to change totally the relationship between FAO and the private sector.

ELCIO GUIMARAES (FAO): That is a very tough question for me and I'm calling on my directors. Well first of all I have to disagree with you. I don't think that your statement regarding what FAO has done or has not done is fully correct. You are looking at it from a different angle, so I would like to ask you to allow me to disagree with you on that. The second part is that the International Treaty and all the instruments that have been put into place in countries like your country are being seen as instruments that would allow FAO to act in areas such as plant breeding, such as the seed system and conservation to improve the situation. And you as a member country of FAO have the power in your hands to tell FAO how you want it to handle those issues. Obviously the issue of public-private partnerships within FAO is not a very easy issue to deal with but, again, FAO does not belong to me, FAO belongs to you and your countries so it is up to you and your countries to tell FAO how these issues have to be dealt with and I'm not in a position to defend either side A or side B. What I am in a position to say here is that according to the assessment that we have been making there is a very great demand for strengthening that relationship. If there are mechanisms available for that, let's use them. What I showed you is not what I am doing but what FAO has identified through the survey. The countries that were surveyed told us that the mechanisms are lacking. So that's the message they're seeing from us. So we can change that. So let's do it together and a forum like this is a good opportunity. And I would like you to think about this in the considerations that you are going to make on Thursday.

General Discussion

ORLANDO DE PONTI (ISF): I think this discussion is a very nice bridge to the next part of the program, the general discussion. By the end of the session I will make a summary of what we have learned this morning but before doing so I think it's important also to get some more perceptions of the variety of opinions in the audience. You have listened to five eloquent speakers on all aspects of the complex art of plant breeding. Feel free to ask any question as it is important for us, in these two days and the panel discussion on Thursday to improve our understanding in order to do an even better job in the 10 years ahead. So who wants to take the floor in this general discussion?

MICHAEL LARINDE (FAO): I would just like to go back to the last question, raised by Mr. Burgaud. And I wish to point out that the picture presented is not exactly representative, because some years back FAO started going bottom-top in our policy towards seed. In fact this Conference is evidence of that, because you rarely saw in the past all the five organizations involved here working together towards one goal. And we've done it here. This is one example. This shows changing policy, realizing that private-public partnership is very important and I think FAO is doing that right now. Another example is our work on seed policies, even in African countries, and the most recent at the congress at the African continental level, the African Seed and Biotechnology program which includes everybody, public, private sectors, CG centers, all stakeholders together in a forum to decide how best to move forward to having the same seed policy, to having the same seed activities for Africa. And I must say that we have countries which are very good examples of this: Afghanistan is one. From nothing, from an emergency situation they have built up a very good seed system and we did not stop there: we formed private seed enterprises. Now we have 32 of them. And we are doing similar work in other countries, so the picture is not totally correct. We have not got there yet, but we are moving towards that goal.

FLORA MPANJU (AFRICAN REGIONAL INTELLECTUAL PROPERTY ORGANIZATION): I listened to the previous speaker when he said that plant breeders were disappearing. In Africa the plant breeders rights were not even known, but thanks to GNIS, UPOV and ARIPO, they have got an initiative already. We have had a first meeting for Africans to sensitize themselves about plant breeders rights and that meeting was very successful, and I think Isabel can comment on it: at least we are doing something. We are trying to create the awareness, and we are trying to put plant breeders rights mechanisms in place so that even the private sector, when it arrives, will be protected. So the structure is there. Thank you to GNIS for the second time. My being here is because of GNIS. They have done a lot of things, so whatever the boss is saying is right. There is something going on.

HOSEA SITIENEI (KENYA SEED COMPANY LTD., KENYA): I think that the presentations have been quite excellent. I have two simple questions. I believe we all agree that any new technology has both negative and positive consequences. We've heard about the positives of the new technology. Do we have any negative consequences, in terms of health of the human being, and the environment? That is the first question. The second one is that we have all agreed that the cost of these new technologies is quite high and my worry is that the seed sector globally is going to be dominated by the multinationals and seed is going to be very expensive especially for the farmers in the Third World. Does FAO have any plans to intervene to make seed affordable for the majority of the farmers, especially in developing countries? Because seed is going to be very expensive.

BILL NIEBUR (PIONEER, US): I agree that these are absolutely critically important questions as we stand here today and consider the opportunities. What we know is that plant breeding is an art that has been practiced for many, many decades and what we know today is that we have improved varieties for their nutritional quality, their productivity and their ability to feed a hungry population. We know that the new interventions that we're bringing forth on the regulated side with the novel regulations are being tested in a much more extensive way than anything that we have ever released previously in our history. Well, that doesn't guarantee that there won't be a moment in time in the future. What we know is that hunger is present with us today, starvation is present with us today and the need for increased agricultural productivity is fundamental, primordial, if we are to stabilize the global situation. So we're continuing to invest heavily in the appropriate studies to understand the safety, the productivity and the consequences as we go forward. On your point: we continue to support that regulation because we believe it's the right thing. I think about the second point: the cost is high and that's why the private sector is investing today very aggressively but whether it is in computers, or television or communications, costs go down with time. And what we want to do is to continue to drive the cost. The scale of the programs that we've described here today is only possible because we have reduced the costs involved in conducting that technology. And increasingly it becomes relatively straightforward to utilize that technology and what we know is that the participative plant breeding that will go on in West Africa, East Africa, Sub-Saharan Africa, or in general on the sub-continent, will be augmented through these new technologies. But the fundamental need is for the people in the field, looking at the plants ensuring the quality is there; it has never been more important, than it is today. So what I believe is that we'll continue to drive the cost out of the system, we'll continue to drive the regulation, in a more sensible, more straightforward, more predictable manner. Then what we'll do is work with you on what is not really brought up today which is even more critical and this is 'stewardship and beyond': how we steward this technology in a responsible and sustainable way.

USHA BARWALE ZEHR (MAHYCO, INDIA): The only other point that I wanted to add to what Bill has already covered is relating to the costs and the need for a strong public sector. I think the costs are high but they are not prohibitive for the public sector to invest in so that the public sector program is complementary to the private sector program and together they can set up partnerships and bring better products.

ORLANDO DE PONTI (ISF): I would like to follow up because this is an important item, and it is related to a remark by Bill in his presentation, because technology and IP go together due to the huge investments. By the way, this is also evident from the slides presented by Bernard and Marcel; plant breeding always has been very expensive. That's the reason we saw this steep increase in yield only when there was protection of the product. That first started as we have seen and as we know, by the UPOV Convention in 1961. Later on and I would say, because of the advent of biotechnology, we got another system in our industry, that is utility patents. And another very important issue in plant breeding around the world over many, many decades is what I call access for further breeding. So I would like to know what Bill's opinion is on access for further breeding if we are talking patents.

BILL NIEBUR (PIONEER, US): Absolutely, an important question to address and I think that some of the other points in the sessions over the next few days will also address this. I believe that patents have a role to play in certain markets around the world, to foster and increase investment as we go forward in innovation. What we've seen is that where we have a combination of appropriate levels of intellectual property protection, be it plant variety, be it patents, utility or functional process patents, combined with trade secrets, what we find is that we drive genetic gain more effectively and more quickly. And so I believe that a reasonable approach to IP is one that considers the development of the market, considers the development of the industry, and that then allows those participants to be rewarded for the invention and the innovation that they have created. And so really I am absolutely a strong proponent of patents. I don't believe they are appropriate globally. I believe they have a place and a role to play, as do other mechanisms of intellectual property protection.

ISMAHANE ELOUAFI (CANADIAN FOOD INSPECTION AGENCY): I have got a question for Usha and Bill. It is regarding using genetic transformation for complex characters like drought and salt. I am not disputing whatsoever the importance of biotechnology or molecular biology. I am a molecular biologist myself, and I do believe it will help us to breed better crops for the future and it will speed up the process as has been shown for characteristics like resistance where you have a gene-for-gene relationship, but I am asking how realistic it is to pursue research or genetic transformation for drought and salt when we know it is very complex, it's multiple genes, it is minor effects and additives that we have there. So I'm just wondering how much is realistic to do at the public level mostly because I think we need a huge database to do it. Maybe at the private level it will be much more feasible.

USHA BARWALE ZEHR (MAHYCO, INDIA): Drought is a very complex trait and I think as we understand more and more about the different genes and the roles that they play, genetic transformation becomes one mechanism by which we can incorporate some of those genes. I don't think we're going to have a crop which is 100 per cent drought-resistant. Our goal is to improve what levels of resistance or tolerance we have today. Even if it means improving tolerance by 50 per cent of the levels that exist today, and genetic transformation is just one component of that not the only mechanism that will give us the ultimate product.

BILL NIEBUR (PIONEER, US): I think Usha has really captured it well. We really don't see it as one or the other. We really see the approaches as being very complementary. If we look at the maize hybrids that are grown today, our data would suggest they're four times more efficient at utilizing an inch of water in a water-limited environment than the hybrids of the 1980s or the 1990s. And that has really come through effective plant breeding. Our transgenic interventions allow us to change hormonal balance, water-storage mechanisms, plant-sensing mechanisms in shock proteins, and what we're actually seeing as an industry is that we're able to condition the plant to withstand transient water stress. Now what we have to recognize is that it rains, and no farmer wants to have a limit on the amount of productivity that can be realized due to the fact that he or she is carrying a drought-tolerance gene. And so we're really being very, very careful to also study how we supplement plant productivity in rain-fed systems as well as irrigated systems because in many parts of the world, the issue is not rain-fed or irrigated, it's that we're irrigating five times a year, how can we go to two? How can we actually move to a rice production system that irrigates rather than floods? And how can we go to a direct seeded rice situation where we would enable the seed quality and the hybrid vigor to allow it to establish a stand against weeds and not need water to control weeds, and to be able to use water more effectively? So there are a number of opportunities on the agronomic traits that we're pursuing in combination. Not one or the other. But I actually believe very strongly that molecular biology has much to offer.

ORLANDO DE PONTI (ISF): It's very clear that we all, as we are here together discussing plant breeding, want to contribute to the increasing needs of food for everybody. And it's clear that improved varieties will contribute a lot in creating productive agriculture. Agriculture starts with preparing the field, with planting the seed. The better the seed genetically, the better the potential for a good crop; of extreme importance in developing countries. I'm very happy this has been recognized again after being neglected for a period of about 20 years, as has been mentioned by the World Bank. It's also clear from the presentations that plant breeding, with contributions from public and private breeding and the collaboration between public and private breeding, has contributed a lot over the last 50 years. We've learned the percentages and also the various traits like resistance, tolerance, nutritional value etc. It's very important from what I summarize from the presentations where the plateau has been mentioned, and was very clearly mentioned by Marcel Bruins that from the breeding side we believe this increase is still there. There are a lot of rumors around in the world that plant breeding is getting to a plateau. As far as I know from my own experience, no matter what crop we're talking, there is still a steady increase of about 1 per cent per year through genetic improvement. You don't see it so clearly year-by-year but if you take 10 years there is a very clear difference. And it has been very well documented by many of today's presenters.

It means that by continuing our investment, and I say it again, public-private together, we will be able to significantly contribute to the alleviation of hunger and to have a better and more balanced right on food by 2050, when we share this world with more than 9 billion people.

From the historic overviews we have seen it is very clear that intellectual property is important: these were very nice slides. From the moment you start to protect the activities of plant breeding, you see immediately an increase in investment, no matter whether this is in conventional breeding, molecular breeding, whatever we call it, in any technology that brings the potential to a higher level, there is investment; from the public sector as well as from the private sector, but then you should have that possibility. This is very clear right from the start of the protection of plant varieties, somewhere in the middle of the last century. In addition to that, I want to make it very clear, there is of course a need also for utility patent protection for return on investment on different types of technology which contribute to the success of plant breeding.

Yes, there are still many tools in the pipeline. We've seen several of them: it is a fascinating toolbox. It is fascinating today to be a plant breeder and to work in a team with probably 10 different types of scientist and other skilled people in order to manage this complex game of recombining genes and technology, etc.

It has been mentioned only very briefly because there is an emphasis on plant breeding and on genetics in the most novel way, but it was mentioned by Marcel in his overview, that there is another technology that is showing increasing potential for the seed industry and this is seed coating, seed treatment, etc. In my view as a seedsman, in terms of seed treatment, seed coating, we're just at the beginning. I have a strong belief that there's a lot of potential. And be assured if you bring the best genetics with the best seed to the farmer you make him or her very, very happy.

The last point is that it is getting more and more complex: I would say it is getting more and more exciting. It is a fascinating field and I hope that we can encourage young people to go into plant breeding, and I really mean plant breeding. I don't mean plant biotechnology, I don't mean bioinformatics, so the more fashionable parts of plant breeding. There are students in the US, in Europe, in India etc. But what we need, we always will need, are plant breeders that are able to make the final selections, to do the final work in the field. Because whatever technology we have, in the end, the best variety is selected by the plant breeder in the field. And the plant breeder is the one, in my view who drives the machinery for improving and getting better varieties.

Session 1. Conclusion, presented by the Chairperson
The role of plant breeding in meeting the multiple challenges of a fast-changing world

- Improved varieties and high quality seeds are basic requirements for productive agriculture, which is the basis of sustainable economic development in developing economies

- Through the efforts of both the public and private sectors, plant breeding has provided an enormous contribution to global agriculture (yield, resistance to biotic stresses, tolerance to abiotic stresses, harvest security, quality traits including nutritional value, etcetera)

- Plant breeding has the ability to significantly contribute in solutions to several of the challenges ahead such as food security, hunger alleviation, increasing nutritional values, and higher input costs Plant breeding and related disciplines and technologies help in mitigating the effects of population growth, climate change and other social and physical challenges

- Intellectual property protection is crucial for a sustainable contribution of plant breeding and seed supply There are still many tools and traits in the pipeline that will prove to be very necessary for the continued supply of high quality varieties and seeds

- Apart from genetic enhancement, other technologies, e.g. quality seed production and seed treatments, contribute substantially to improved seeds, and capacity building in all these areas is urgently needed in developing countries.

Session 2

THE IMPORTANCE OF PLANT GENETIC RESOURCES FOR PLANT BREEDING; ACCESS AND BENEFIT SHARING

Chairperson: Mr. BERT VISSER,
Director Centre for Genetic Resources, Wageningen University and Research Centre (The Netherlands)

- **The use of plant genetic resources in plant breeding**
  Ms. ANKE VAN DEN HURK, Dutch Seed Trade Association Plantum (The Netherlands)

- **Facilitating access and ensuring benefit sharing globally: the Multilateral System of the International Treaty on PGRFA (ITPGRFA)**
  Ms. COSIMA HUFLER, Chair of the Governing Body of the ITPGRFA

- **Exchanging material in the daily business: the operations of the Multilateral System and the Standard Material Transfer Agreement (SMTA)**
  Mr. SHAKEEL BHATTI, Secretary of the ITPGRFA

- **Working with the Multilateral System: experiences of a seed company – representatives from private sector**
  Mr. JOEP LAMBALK, Director Enza Zaden R&D B.V. (The Netherlands)

- **Implementing the International Treaty at the national level: what is the impact on the seed sector?**
  Ms. YLVA TILANDER, Deputy Director, Ministry of Agriculture (Sweden)

General discussion

Conclusion, presented by the Chairperson

THE USE OF GENETIC RESOURCES IN PLANT BREEDING

Ms ANKE VAN DEN HURK*

In this paper the relationship between plant genetic resources and plant breeding is described. Furthermore, we explain how the existing balance between the two has changed since the ratification of the Convention on Biological Diversity (CBD) and the International Treaty on Plant Genetic Resources for Food and Agriculture (IT PGRFA).

Plant Breeding

Plant breeding is described in various ways as can be seen in Box 1.

Box 1 Definitions of Plant Breeding

Plant breeding is the art and science of changing the genetics of plants for the benefit of humankind.
http://en.wikipedia.org/wiki/Plant_breeding

Plant breeding is the use of techniques involving crossing plants to produce varieties with particular characteristics (traits), which are carried in the genes of the plants and passed on to future plant generations.
http://www.ers.usda.gov/Briefing/Biotechnology/glossary.htm

Plant breeding is the purposeful manipulation of plant species in order to create desired genotypes and phenotypes for specific purposes, such as food production, forestry, and horticulture.
http://en.citizendium.org/wiki/Plant_breeding

It does not matter how plant breeding is described, all definitions have one thing in common; genes are recombined either through selection, crossing or other breeding techniques using genetic resources and resulting again in genetic resources.

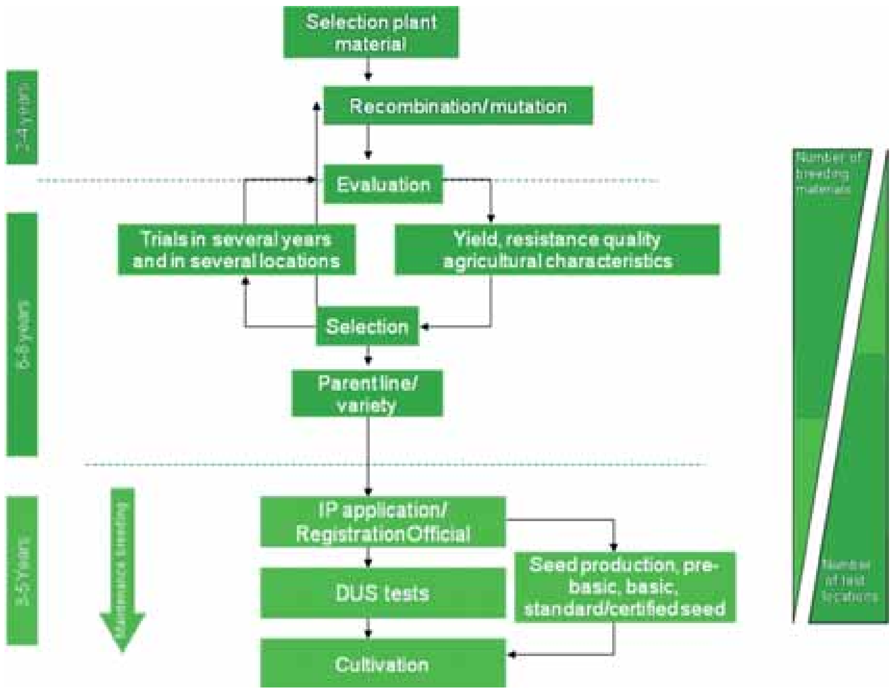
In Fig. 1 the process of plant breeding is described. This process can be divided into three major phases: 1. Recombination; 2. Selection; 3. Registration and Commercialization.

The recombination phase is used to try and get all the preferred genes together in the starting material of the breeding process, be it through mutations, crossing or other more advanced techniques. This may take from two to four years.

Once the genes are put together, the selection process starts. During this phase the best combination of genes is selected in such a way that it becomes stable either as a variety or through parent lines. The selection procedure is long and tedious and may take from six to eight years. At the beginning of the breeding process, selection is done in one place, but later on in the selection it takes place at other locations to see if the material is adapted to the climate and meets the needs of the different farmers and/or growers.

* Dutch Seed Trade Association Plantum, The Netherlands

Fig. 1 Plant Breeding Scheme



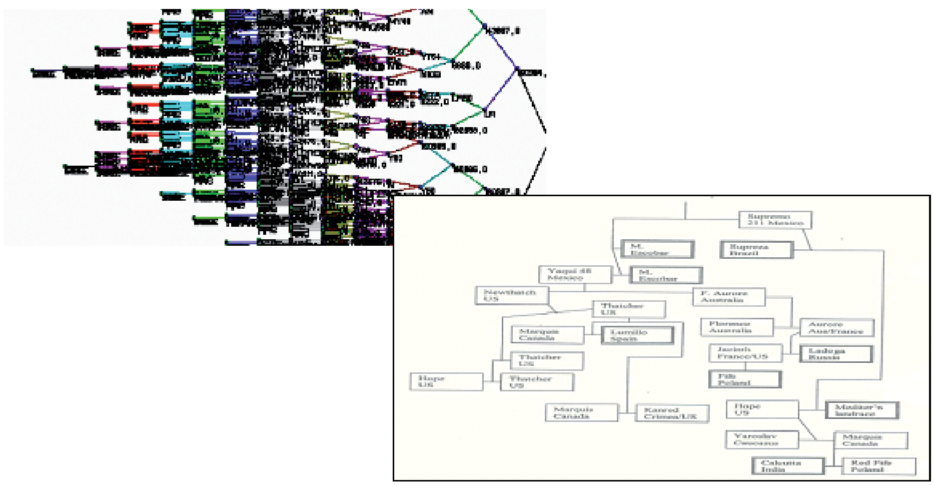
During the third phase, the selected varieties are registered, if relevant intellectual property rights (IPR) are applied for, and seed production will take place to provide the growers with sufficient quality seeds. The latter phase will take another three to five years.

Genetic Resources in the Plant Breeding Process

Genetic resources can be directly used as the basis of the plant breeding process, but they may also be indirectly used.

Direct use implies that the genetic resources are used to recombine genes and develop an end-product, a plant variety. This can be done through crossing and/or other breeding techniques. The history and/or type of the genetic resources that are used for recombination may differ. In most cases the plant breeder will make use of modern plant varieties that consist of good sets of genes. This should result in better varieties with an even better set of characteristics like high yield, disease resistance, high quality, etc. In some cases the desired characteristics cannot be found in modern varieties and then other genetic resources like landraces and wild relatives are used. Material from research projects may also be used. Furthermore, genes from other organisms like microbials and pathogens may be used.

Fig. 2 The pedigree of the Sonalika wheat variety

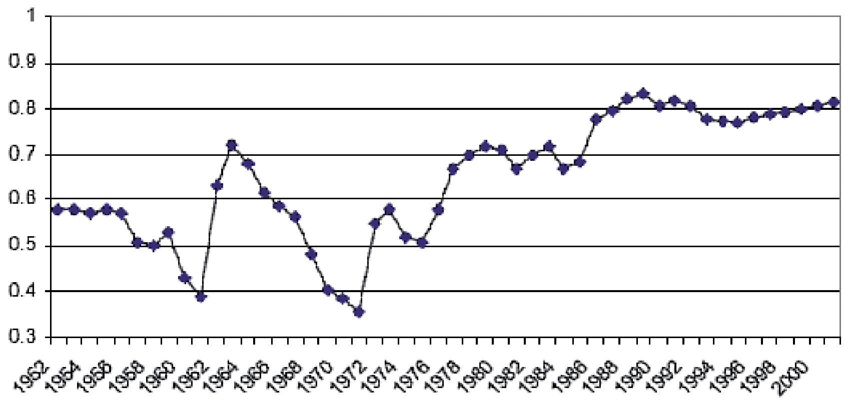


Therefore, plant breeding results in varieties consisting of new gene combinations from genetic resources; both from recombination within the species and recombination between species. Fig. 2 demonstrates in a very clear manner that recombinations are continuously being made to get new varieties. In this example the pedigree, in other words the crossing history, of the Sonalika wheat variety is shown.

Genetic resources are used in the plant-breeding sector to create new plant varieties, which are again genetic resources. Therefore it can be seen that plant breeding can also have a positive impact on biodiversity. Through plant breeding, new variations, new diversity may be created. An example of improvement in diversity is shown in Fig. 3. Lang and Bedo (2004)[1] showed in their study that a pedigree analysis on the Hungarian wheat varieties registered over the last 50 years indicated a high increase in genetic diversity. Breeders have used a wide range of genetic resources to arrive at the new wheat varieties. Moreover, farmers are now using more varieties than in the past.

In an article on genetic erosion and the role of plant breeding, Van der Wouw et al. (2009)[2] identify a phase where the access by breeders to exotic parent materials increases the diversity (at the allelic level). New breeding techniques and access to gene banks allow for the utilization of genes from related species and transformation techniques may introduce genes from a much wider range of genetic resources. Moreover, the increased breeding efficiency provided by the use of molecular markers supports the breeding of varieties for specific uses and regions, creating larger numbers of varieties. A study of 20 independent analyses, mainly in Europe and North America, showed that reduction of biodiversity through modernization of agriculture could be seen in the 1960s when diversity in the crops researched was low. However, diversity rose again from then on until the end of the century. These trends over the last decades demonstrate that plant breeding has a positive influence on biodiversity at the genetic level, i.e. allelic richness and evenness, which is different from the number of varieties that are available to farmers. Van der Wouw et al. (2009) state that further increase will depend on various issues.

Fig. 3 Weighted Diversity in Hungarian Wheat Production (calculated from COP, number of varieties and market share of varieties; range 0 to 1)



Recombination and use of genetic resources are not limited to one plant breeder: plant breeders made, have made, and will make use of each others' genetic resources, as well as of genetic resources from different countries and backgrounds. Plant species have moved from one side to the other side of the world and may have obtained importance in a new region and/or country. Fig. 4 demonstrates the spread of sugar cane. It is believed that Papua New Guinea and the surrounding area was the center of origin for sugar cane. From there it moved to the north of India where a secondary center of origin developed. Then it moved further around the world, with Brazil currently the top producer.

It is not only that plant species move around the world, but also that those species may be used in a different way and therefore gain importance. Sugar cane for example is now also important for

[1] Láng, L., Bedo, Z. 2004. Changes in Genetic Diversity of the Hungarian Wheat Varieties registered over the last Fifty Years. In Genetic Variation for Plant Breeding. Proceedings of the 17th EUCARPIA General Congress, Tulln, Austria, Sept. 8-11, 2004.

[2] Van der Wouw Chris Kik, Theo van Hintum, Rob van Treuren and Bert Visser,. Genetic Erosion in Crops: Concept, Research Results and Challenges, 2009 in press. Centre for Genetic Resources, the Netherlands (CGN) – Wageningen University and Research Center, Wageningen, The Netherlands.

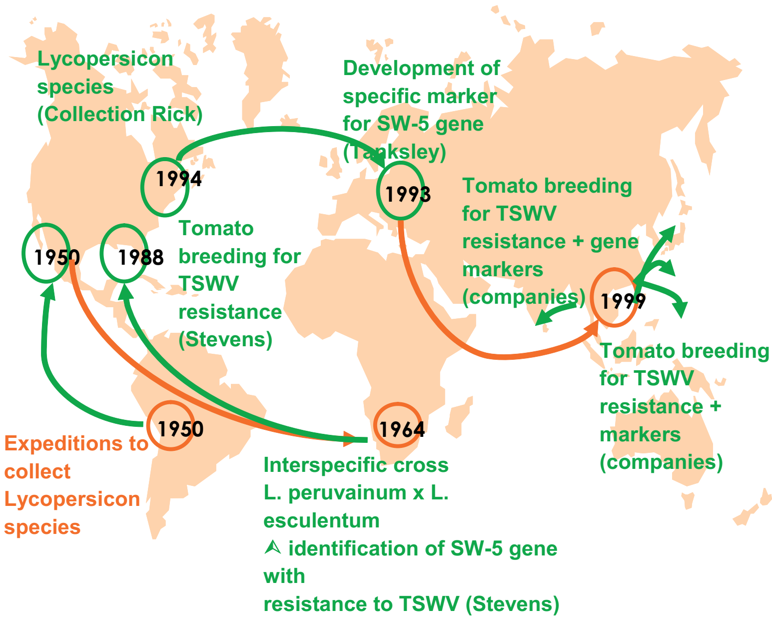
ethanol production. Furthermore, crops may adapt and move to different regions. Maize for example has moved to the north of Europe, while sugar beet has been adapted for tropical conditions.

Fig. 4 Domestication, the Spread of Sugar Cane over the World

The flow of tomato resistance genes for the Tomato Spotted Wilt Virus (TSMV) in Fig. 5 show that interesting genes are also used by different breeders and in different continents.

From the above it can be concluded that no plant breeder, no nation, is completely independent in terms of genetic resources: both developed and developing countries have come to rely on non-indigenous crops for their food and agricultural supply. A study assessing the degree of a country's dependence on non-indigenous crops (measured in terms of calorific contribution to nutrition from crops whose center of diversity is outside the country in question) has shown that all countries grow or import crops from distant lands (Palacios, 1998)[3]. Table 1 shows the dependency levels for a range of countries.

Fig. 5 Flow of TSWV-Resistant Germplasm around the World



From the figures given by Palicios it can be seen that, for example, Ghana is just as dependent on crops originating outside of Ghana (70 to 81 per cent), as Italy is on crops originating outside of Italy (71 to 81 per cent).

[3] Flores Palacios X (1998) Contribution to the Estimation of Countries' Interdependence in the Area of Plant Genetic Resources. FAO, Commission on Genetic Resources for Food and Agriculture.

Table 1 Levels of Dependency on Genetic Resources from Outside the Countries

Country	*Dependency (%)*	*Main source of energy supply*	*Primary region of diversity of crops*
China Japan Republic of Korea	46 - 55 43 - 61 30 - 54	Non-native - wheat, sugar, maize, potato Native - rice and soybean	East Asia - rice, soybean, orange, Brassica, millet, tea, onion
Bangladesh India Nepal	14 - 21 35 - 47 47 - 57	Non-native - wheat, maize Native - rice, sugar cane, millet	South Asia - rice, banana, sugar-cane, sesame, millet, Brassica rapa, B juncea
Kenya South Africa Ethiopia	89 - 98 90 - 98 28 - 56	Non-native - Phaseolus, maize, sweet potato, potato, cassava, banana, plantain, wheat, rice Native (for Ethiopia) - tef, Avena Abyssinian, Brassica carinata	East and Southern Africa - sorghum, millet, yam
Brazil Andean Region Argentina Colombia	81 - 94 89 - 95 84 - 94	Non-native - wheat, sugar, rice, maize, soy-bean, plantain, banana Native - potato, Phaseolus (for Andean Re-gion); cassava (Brazil)	Andean region – pineapple groundnut, sweet potato, tomato, cocoa, Phaseolus, potato, cassava,
US Canada	77 - 100 84 - 99	Non-local - wheat, sugar, soybean, potato, maize, barley, rice, groundnut	North America - sunflower

Source: Papacios, 1998

Plant genetic resources are also frequently used indirectly in the plant-breeding process. “Indirectly” means that genes are not recombined or transferred and plant genetic resources may be used in test trials. Standard varieties, for example, are used to see if newly developed varieties are better or not. This may be in relation to yield, but can also be related to resistance or any other important characteristic.

Pathogens are other genetic resources that may be used in the breeding process. To measure if plants are resistant to certain diseases it is important for plants to be infected with the pathogen. Hence, the pathogen serves as test material.

Another group of genetic resources that are important in the breeding process are pollinators. Bees, humble bees and flies, are necessary and frequently used in the seed production of various plant species.

Conclusion: Plant breeding equals to a continuous flow of genetic resources from anywhere to everywhere.

Maintenance of Genetic Resources

As genetic resources are very important for the plant-breeding sector, the sector is taking care or assisting in the maintenance of genetic resources. First of all, plant breeders maintain genetic resources in their own collections. These collections consist of breeding materials, modern varieties, landraces and wild relatives. The collections maintained are principally for their own use. However, if necessary, relevant materials may be exchanged or even offered for reintegration in nature.

Second, plant-breeding companies support gene banks and/or botanical gardens. The Dutch breeding companies, for example, account for 10 to15 per cent of the budget of the Dutch gene bank: they do that by multiplying accessions from the gene bank. Furthermore, they assist in the characterization and evaluation of gene bank accessions. In some cases, financial support is provided to gene banks in order to maintain their facilities and their genetic resources. In exchange, plant breeders may make use of the accessions for their breeding activities without further consent.

Lastly, support may be provided for the collection missions of gene banks or other organizations for maintenance and sustainable use of those genetic resources. Lately, the Dutch vegetable seed companies have supported collection missions on spinach and onion/leek of the Dutch gene bank.

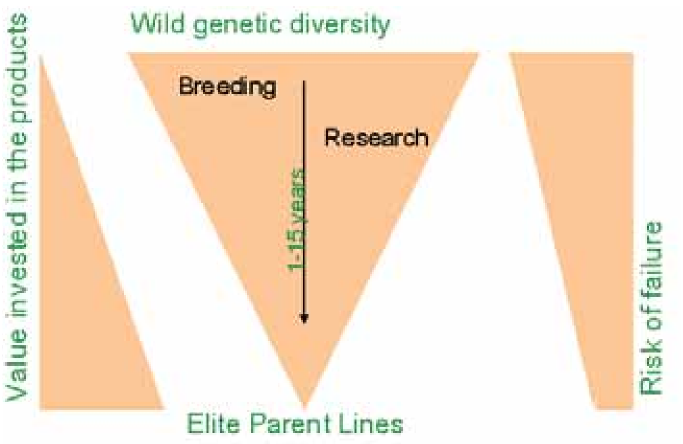
Conclusion: Without maintenance of genetic resources = no availability of genetic resources = no plant breeding

Availability of Genetic Resources

As seen earlier in the text, genetic resources are closely linked to plant breeding. Hence, it is important that they are easily available for plant breeders to do their work. In addition to materials from their own collections, plant breeders obtain traditional genetic resources from gene banks, botanical gardens, farmers, markets and sometimes from the wild. Plant breeders make use of any opportunity for obtaining new materials. Most materials have no value at the stage they are found, but in some cases interesting genes can be discovered in those materials after a lot work of recombination and selection.

Fig. 6 demonstrates schematically what the consequences are of the use of different genetic resources in the breeding process. Looking at the top of the chart we see that wild relatives as such have limited value, as they are distanced from an elite parent line or a variety useful for grower or farmer. The value invested in a wild relative for further improvement is in general still very limited. Where wild relatives are used for plant breeding the number of genetic resources should be high. The chance of failure is still quite important and a lot of work needs to be done to get the right set of characteristics in the variety. During the process a lot of genetic resources will be discarded as they have no practical use.

Fig. 6 Schematic Representation of the Increase of Value of Genetic Resources through Research, the Number of Genetic Resources required and the Risk in using Genetic Resources, ranging from Wild Relatives to Elite Parent Lines



The more we know on plant genetic resources, the less accessions for the breeding process are required. In Fig. 6 this is represented in the central triangle. Moreover, the more we know on the variety the more will have been invested in research: this is shown in the left triangle in Fig. 6. As more is known on genetic resources, these have a greater value for the final variety, the risk of failure in the plant breeding process by using the material will be lower. The latter is demonstrated on the right in Fig. 6.

Thus, it can be seen that availability of genetic resources is important for plant breeders to do their work: a continuous flow is important. Moreover, it is also important not only that wild relatives are available, but also that materials that are further developed, whether research material or even final varieties are available. Plant breeders have recognized this importance while developing an IP system: the plant variety protection system. With this system the product as such can be protected for further multiplication. However, the protected products can be used for further research and breeding without any further consent of the owner and without any cost after commercialization. Therefore, it can be concluded that the so-called breeders' exemption is a benefit in itself.

Conclusion: The Availability of Genetic Resources leads to Benefit Sharing

Conventions on Biodiversity and Plant Genetic Resources

Up to 1992, the plant-breeding process, the exchange of genetic resources, the maintenance of these resources and sharing of benefits arising from their use and exchange, such as breeders' exemption, support in maintenance of genetic resources, capacity building and research projects, worked in harmony as genetic resources were seen as common heritage. After 1992, in particular after December 29, 1993 when the Convention on Biological Diversity (CBD) was ratified, genetic resources were no longer seen as common heritage, but as resources with sovereign rights.

The goals of the CBD are threefold:

- conserving genetic resources;
- sustainable use of genetic resources; and
- organizing Access and Benefit-Sharing (ABS).

The latter, especially, has important implications on the traditional working methods of the plant-breeding sector. A traditional balance of activities as described above has been disrupted as genetic resources can no longer be obtained without prior informed consent and mutually agreed terms.

Fig. 7 Demonstration of Different Products that may or may not be linked to Access and Benefit Sharing

How to organize prior informed consent and how to settle mutually agreed terms is not yet clear. Political debates/negotiations on establishing an international regime on access and benefit-sharing have been taking place for many years. It is planned that a regime should be ready by 2010, but it is unsure whether this will be reached as the expectations of the different countries are very different. Fig. 7 shows all the products that may or may not be linked to benefit-sharing. Some countries are of the opinion that the ABS regime should only deal with genetic resources, while others think it should not only relate to genetic resources, but also to biological resources and their derivatives and products.

For plant genetic resources for food and agriculture a specific arrangement existed before the establishment of the CBD. The International Undertaking on Plant Genetic Resources for Food and Agriculture stimulated the exchange and use of plant genetic resources for food and agriculture. As this was based on common heritage, it needed to be renegotiated. This resulted in the ratification of the International Treaty on Plant Genetic Resources for Food and Agriculture (IT PGRFA) on June 21, 2004. The conservation and sustainable use of plant genetic resources are the first two goals of the IT PGRFA. The third objective is related to ABS. In the IT PGRFA a special multilateral system has been developed for a limited number of plant species in order to make the ABS arrangements simple, efficient and equal for all players by using an internationally accepted Standard Material Transfer Agreement (SMTA).

The ratification of the CBD and IT PGRFA has wide implications for the plant-breeding sector. Flows of genetic resources are interrupted and it is no longer automatic that plant breeders can use any resources they like. There are new or different systems for obtaining genetic resources and the existing benefit-sharing mechanism may no longer suffice. Moreover, it should be recognized that new systems are often not in place and it is not clear how ABS should be organized.

Therefore, obtaining plant genetic resources may be more difficult if not impossible; it may result in burdensome administrative procedures and lack of transparency on exchange of genetic resources: the plant-breeding process may slow down. Furthermore, it should be realized that not using genetic resources may result in their loss.

The multilateral system of the IT PGRFA solves some of the problems mentioned above in obtaining access and organizing benefit-sharing. The use of the SMTA is simple, efficient and creates a level playing field. Unfortunately the system is only limited to a number of species, not including some important field crops like soybean, a lot of important vegetable species and all ornamentals.

The multilateral system recognizes the importance of intellectual property.. Moreover, in the SMTA the value of the breeders' exemption is recognized as a benefit. No obligatory financial benefit-sharing is required when new varieties are freely available for further research and breeding.

Conclusion

Plant breeding and genetic resources cannot be seen separately; they strengthen each other and one cannot exist without the other. In light of the CBD and IT PGRFA it is important with the implementation of the ABS systems in both Conventions that a continuous flow of genetic resources is guaranteed under reasonable conditions. The multilateral system of the IT PGRFA seems to be most consistent with the plant-breeding sector. It would therefore be useful to expand the system to cover the whole breeding sector.

Discussion

DOMINIQUE DESSAUW (CIRAD FRANCE): Just for the sake of clarification: as the breeders' exemption is only valid under the UPOV system, this advantage only applies to the UPOV system. But you have other plant variety protection in the world, like the patents in the US, where you cannot use the protected varieties for further breeding without the agreement of the owner. The breeders' exemption is therefore only available under the UPOV system.

AAD VAN ELSEN (PLANTUM NETHERLANDS): I would like to comment on the last remark from the gentleman from CIRAD. I think that is a very valuable comment and this is why within Plantum we decided that we wanted to change our position with regards to the breeders' rights system and the patent system. We have now adopted the position that any plant material should be freely usable without any consequences for it, and even in the case where you develop new material and innovate on old and protected material, be it varieties or plants protected by plant breeders' rights or by patents, you shouldn't be bothered with licenses anymore. That, at least, is the position we have taken and I hope we will get a lot of support for it. It is precisely touching on the point that we need to get access in the best way possible.

FACILITATING ACCESS AND ENSURING BENEFIT-SHARING GLOBALLY: THE MULTILATERAL SYSTEM OF THE INTERNATIONAL TREATY ON PGRFA

Ms. COSIMA HUFLER*

Introduction

The FAO estimates that over the course of history about 10,000 different crops have been used for food production for humankind and in the last century alone, 75 per cent of these crops have been lost.

Nowadays, only 120 crops feed 90 per cent of the world's population and only four of them provide 60 per cent of their dietary energy. These four key food plants are rice, maize, wheat and potato.

For these, and indeed for many other crops, the following holds true: over centuries, generations of farmers have created countless varieties, often far from a plant's center of origin and irrespective of national boundaries.

As a result of the loss in crops and the dependence on a small number of species, we now live in a world in which no one single country can be considered self-sufficient in terms of being able to survive solely on indigenous crops within its borders. Interdependence and global cooperation will be ever more important with the projected consequences of climate change and potentially new diseases or pests.

It is projected that with a rise in mean global temperature by only 2 per cent, yields in Africa, Asia and Latin America could decline by 20 to 40 per cent. Severely increased risks of drought and flooding all over the world are already being felt.

The International Treaty on Plant Genetic Resources for Food and Agriculture, which entered into force in 2004, gives due recognition to these developments. It is an international agreement with the overall goal of supporting sustainable agriculture and global food security.

The Treaty allows governments, farmers, research institutes and agro-industries to work together by pooling their genetic resources and sharing the benefits from their use – thus protecting and enhancing our food crops while giving fair recognition and benefits to local farmers who have nurtured these crops through the millennia.

The Treaty covers all plant genetic resources for food and agriculture and recognizes, in accordance with the Rio Principles and the Convention on Biological Diversity, the sovereign rights of states over their own plant genetic resources for food and agriculture.

It is in the exercise of those sovereign rights that the Contracting Parties to the Treaty have established a Multilateral System both to facilitate access to plant genetic resources for food and agriculture and to share, in a fair and equitable way, the benefits arising from the utilization of these resources.

* Chair of the Governing Body of the ITPGRFA

What does the Multilateral System mean and where are the Gains in Practice?

On the Access Side

The Treaty's truly innovative solution to access and benefit-sharing is its declaration that 64 of our most important crops will comprise a pool of genetic resources that are accessible to everyone: this is the Multilateral System. On ratifying the Treaty, countries agree to make their genetic diversity and related information about the crops stored in their gene banks available to all.

The Multilateral System is thus an easily accessible global pool of genetic resources that is available to potential users under the terms and conditions of the Standard Material Transfer Agreement.

The 64 crops it comprises represent 80 per cent of the food we derive from plants, encompassing to date more than 600,000 unique varieties. This list of crops covered by the Multilateral System was established according to the criteria of food security and interdependence.

Access to genetic materials within the MLS is through the collections in the world's gene banks. Under the Treaty, collections of local, national and international gene banks will be put in the public domain.

These can include collections of local seeds kept in small refrigeration units of research labs, national seed collections housed in government ministries or research center collections that contain all known varieties of a crop from around the world.

They also include the vast collections of the Consultative Group for International Agricultural Research (CGIAR), a consortium of 15 international research centers.

The Multilateral System therefore provides scientific institutions and private sector plant breeders with the opportunity to work with, and potentially to improve, the wide range of materials stored in gene banks worldwide or even crops growing in fields.

On the Benefit-Sharing Side

Those who access genetic materials through the Multilateral System agree to share any benefits from their use through the established benefit-sharing mechanisms.

These include the sharing of monetary and other benefits arising from commercialization, in accordance with the terms and conditions of the SMTA:

- recipients of genetic resources from the Multilateral System pay an equitable share of commercial benefits whenever a product resulting from those resources is commercialized with restrictions for further research and breeding
- the funds thus acquired will form part of the Treaty's Funding Strategy and will flow primarily to farmers, especially in developing countries and countries with economies in transition, who conserve and use plant genetic resources for food and agriculture.

And the sharing of non-monetary benefits:

- exchange of information, technology transfer and capacity building
- managing and conserving plant genetic resources on farms
- sustainable use of plant genetic resources

The International Treaty on PGRFA, through its Multilateral System, establishes the legal conditions for building and sustaining an effective and efficient system for the utilization of plant genetic resources by plant breeders for sustainable agriculture and food security. Since the resources are treated as a pooled good, there is no requirement for negotiations of individual contracts with individual owners. This means transaction costs are reduced significantly.

Particular importance will be devoted to the information system of the MLS and its key role as the core of the International Treaty.

The Role of Information in the Implementation of the Multilateral System

The Multilateral System is clearly a major success in that a number of its constituent elements have been or are being put in place, in particular the Standard Material Transfer Agreement. This also shows that over 100,000 accessions are being exchanged annually through the Standard Material Transfer Agreement.

The great bulk of this exchange is represented by the collections of the International Agricultural Research Centers of the Consultative Group on International Agricultural Research and other international institutions, and of established gene banks in developed countries. Therefore the system requires measures for further strengthening and promotion of an even wider application.

For a plant breeder seeking useful materials, the Multilateral System is only as good as the information systems that describe these materials. Providing such information is a "distributed" function, not managed from the center, but the task of gene bank and information system managers throughout the world.

Identification and documentation of material within the Multilateral System has so far been partial. It is vital for the long-term effectiveness of the system that Contracting Parties now take the necessary steps to document their relevant plant genetic resources and to facilitate access to them. There is a need to support the relevant authorities and entities, particularly in developing countries, in improving the information base.

Tackling these matters as a priority will support Contracting Parties in overcoming their difficulties in making their relevant plant genetic resources for food and agriculture available through the Multilateral System and the Standard Material Transfer Agreement.

During the past biennium, the Secretary has worked with the Contracting Parties and other users of the Multilateral System, to promote the exchange of experience and the documentation of best practices, help improve understanding of the Multilateral System and the Standard Material Transfer Agreement and resolve problems that were identified.

It is therefore proposed that, during the forthcoming biennium, this work be continued as a priority through a variety of proposed measures aimed in particular at strengthening national capacity to implement the Multilateral System, and by providing further guidance in the implementation of the SMTA.

Conclusion

Plant breeders worldwide pursue their profession in search of ever-increased quality of crops. Is it to increase the yield, to tolerance of environmental pressures, resistance to viruses, fungi and bacteria or to increase tolerance to pests and herbicides.

The challenges of our time, in particular global warming and the ever-growing population numbers will make plant breeding ever more important to humankind.

Seed exchange, from which all eventually benefit, has been the reality of agriculture since its beginning. Our enormous and growing world population will only be fed if we continue to draw freely on the widest possible range of resources at all times.

The IT PGRFA established the system in response to the current challenges and will increase the world's adaptability to these challenges. The Multilateral System of the IT PGRFA provides gains to plant breeding both through access to currently 600,000 unique varieties - and these numbers are ever growing – as well as through benefit-sharing, notably the information provided through the system. And in all fairness, access in itself is already a major benefit.

Discussion

ORLANDO DE PONTI (ISF): We have seen two excellent presentations, but I notice one important difference: Ms. Hufler, can you explain to me why on your slides on non-monetary benefits you did not mention the important benefit of unrestricted access for further breeding?

COSIMA HUFLER (ITPGRFA): I think this is mainly in the way of how I conceptualized the presentation. Since there are different perceptions of access and benefit-sharing in the world, you as a plant breeder would see that free access to genetic diversity and to the crops is already a benefit in itself. However, in a developing world where countries struggle to actually have the means to be able to nurture and conserve their local genetic varieties, it is important that they obtain the funds to actually undertake these measures. This is the other aspect of benefit-sharing, and therefore I think it is a question of conceptualizing. Yet I agree that it is also a fact that free access, as is stated in my conclusion, is a benefit for all.

BERNARD LE BUANEC (ORGANIZING COMMITTEE): Do you think that there is any chance that the list of crops in Annex I will be expanded one day? There are still some important crops for food and agriculture that are not on that list. What should we do about that?

COSIMA HUFLER (ITPGRFA): If I could foresee the future – this is a very difficult question to respond to because of course it is for political discussion. I think for merely pragmatic reasons, once the system is fully up and running and is being used widely, then there might be the tendency that people would want to extend it.

EXCHANGING MATERIAL IN THE DAILY BUSINESS: THE OPERATIONS OF THE MULTILATERAL SYSTEM AND THE STANDARD MATERIAL TRANSFER AGREEMENT (SMTA)

Dr. SHAKEEL BHATTI*

Introduction

The Multilateral System (MLS) of the International Treaty on Plant Genetic Resources for Food and Agriculture (the Treaty) is the first multilaterally managed global public good of the 21st century – a global gene pool of more than 1.1 million samples of plant genetic material governed collectively and multilaterally by its 121 Contracting Parties (CPs). Through this gene pool the CPs control – and are responsible for – the basis of more than 80 per cent of the world's food from plants, and are our most important tool for adapting to climate change in agriculture in years to come.

Over the biennium 2008-09 this MLS has been operationalized and become functional. In less than two years, the Treaty has gone from a legal text to a practical reality for agriculture worldwide. The Consultative Group on International Agricultural Research (CGIAR) carried out more than 440,000 transfers of genetic material per year using the SMTA of the Treaty.

The Multilateral System

At its First Session in 2006, the Governing Body of the Treaty (GB) decided that the focus in the implementation of the Treaty should be "to make the MLS functional". In order to so, the GB adopted the SMTA - a bilateral contract that facilitates and regulates exchanges of genetic material under the MLS between providers and recipients.

The SMTA contains provisions on monetary and non-monetary benefit-sharing, and provides - in case of dispute - for a Third Party Beneficiary (TPB) that represents the interest of the MLS. However, a number of legal, technical and administrative uncertainties still remain, and developing countries in particular have requested assistance in factoring the SMTA. At its Third Session in June 2009, the GB therefore took the necessary decisions and gave adequate guidance to the Secretary and the CPs to overcome these uncertainties over the next biennium 2010 - 2011.

In order to have a clear and accurate picture of what is actually available "in" the MLS it is important that countries take legal and administrative steps to identify their materials that are part of the MLS; and that these be adequately documented, so that they can be used by plant breeders, farmers, researchers and other stakeholders.

At its Third Session the GB in Resolution 4/2009 therefore requested all CPs to report on their plant genetic resources for food and agriculture (PGRFA) that are in the MLS and to take measures to make information on these resources available to potential users. It also encouraged CPs to provide information on the collections of legal persons not part of the government, whom they regard as forming part of their national plant genetic resource systems. Several CPs, as well as the first private sector bodies, have already informed the Secretariat of the Treaty of the materials which are included in the MLS. Furthermore, efficient coordination and integration of existing information systems on agricultural plant genetic resources are being developed in a wide partnership with the CGIAR Centers, the Global Crop Diversity Trust, and national and regional gene banks.

* Secretary of the ITPGRFA

However, the MLS and the implementation of the SMTA are not self-executing: CPs must engage with the system, manage the system and provide minimum support to users in order to overcome initial uncertainties and hesitancies. Priorities for the moment are to resolve such uncertainties that are preventing some providers, including some CPs, from effectively incorporating their materials into the MLS; and to document and make visible the materials that are in the MLS, which is the conditio sine qua non in order for the Treaty to successfully address the challenges the world currently faces: climate change, population growth and persistent poverty.

In order to regulate the day-to-day management of the Treaty's systems and interaction with stakeholder communities, the GB requested – in Resolution 4/2009 – all CPs to establish policy, legal and administrative measures to provide facilitated access to PGRFA through the use of the SMTA. It urged developed country CPs to provide appropriate assistance to developing countries for capacity-building, awareness-raising, promoting the exchange of information among those responsible for implementing the SMTA at the national level and electronic management of the SMTA and related reporting.

The Benefit-Sharing Fund

Under its Funding Strategy the Treaty establishes a Benefit-Sharing Fund with the aim of supporting conservation projects, especially in developing country CPs. This fund is fed by voluntary and mandatory payments by governments, the private sector, and other organizations.

There have been two quantum leaps which the Treaty has achieved under the Funding Strategy since the Second Session of its GB:

First, in accordance with the mandate the CPs gave it, the Bureau of the GB in 2009 approved the first 11 small-scale projects to be funded by the Benefit-Sharing Fund. These grants amount to a total cost of more than half a million US dollars. By successfully completing this first test-run of benefit-sharing under the Treaty, it has proved that international benefit-sharing within a binding legal architecture on a multilateral basis does work.

The second advancement offers a concrete and practical perspective on how to address the needs that were expressed by many agricultural stakeholders worldwide within a few weeks of the call for project proposals: a Strategic Plan for the Benefit-Sharing Fund of the Funding Strategy has been adopted which sets a fund-raising objective of 116 million US dollars and a working target of 50 milion US dollars from 2009 to 2014.

Discussion

MAGNI BJARNASON (VIBHA SEEDS): What about plant species that are not on the Annex I list of the 64 crops but might fall under the CBD? I am thinking of crops like Jatropha. What does a person have to do if he wants to go to a country in order to collect accessions and take them to some other place? What processes are required, if any, in this case?

SHAKEEL BHATTI (ITPGRFA): In fact the question of non-Annex I material falls into two particular aspects: The first one is that non-Annex I material, that has been brought under the Treaty in the form of so-called Article 15 agreements between the institution holding those materials and the Governing Body, is governed by a second MTA which has also been adopted by the Governing Body and is essentially identical with the SMTA, except for one footnote. The second aspect is that for non-Annex I material that is not under such agreements and resides in Contracting Parties, the decision is entirely up to the Contracting Parties. There is nothing to prevent Contracting Parties from transferring such material using the SMTA. At the same time the Treaty does not provide or require transfers under the SMTA, and indeed some Contracting Parties have included non-Annex I material by a purely voluntary decision.

BERT VISSER (WAGENINGEN UNIVERSITY, NETHERLANDS): So the answer is, if material is not brought under the Multilateral System, then the CBD rules, which are based on national sovereignty and national jurisdiction, are applied.

ZEWDIE BISHAW (ICARDA): From your presentation one can see that most of the material included in the Multilateral System comes from the CG centers, which are also the major holders of the gene pool, and that some countries are to some extent reluctant in providing germplasm. Do you see any trend in other countries joining and bringing their collection under the Treaty, as well as in terms of the exchange of the materials?

SHAKEEL BHATTI (ITPGRFA): The reason why I was mostly quoting data and figures from the CGIAR is because from the CG we have the most systematic and complete data set on SMTA operations and on transfers of material. As you saw in the videos on the information tools that have been developed, we are currently working on obtaining comprehensive and reliable data on SMTA use and exchange under SMTAs at national and regional levels, but this is quite a major exercise. So that being the case, as a caveat, it is indeed right that in the first biennium a number of countries were still in the early stages and considering how to apply and implement the Treaty domestically. I think that in the third session of the Governing Body a number of concerns were really discussed and there has been quite an increasing trend of inclusion of material. We have seen that both developing countries, e.g. Brazil, Namibia and Zambia, and developed countries such as the Netherlands, Germany and all the members of the Nordic gene bank, have notified inclusion of material and in some cases also material that goes beyond Annex I. So there is, I think, a clearly identifiable trend towards an increasing momentum in inclusion of material.

BERT VISSER (WAGENINGEN UNIVERSITY, NETHERLANDS): Just to add some figures to this answer, in addition to the over 600.000 accessions in the CG-system, from Europe alone 250.000 accessions have already been added to the Multilateral System.

WORKING WITH THE MULTILATERAL SYSTEM: EXPERIENCES OF A SEED COMPANY – REPRESENTATIVES FROM PRIVATE SECTOR

Drs. J.J.M. LAMBALK*

Within Enza Zaden, a vegetable breeding company located in Enkhuizen, Netherlands, we have active breeding programs in 20 vegetable crops. Actually only five of these crops are listed in Annex 1 of the International Treaty, which means that the majority of our crops are not included in the MLS. In practice, however, many gene banks in Europe already implement and use a SMTA for MLS but also for non-MLS vegetable crops.

Certain gene banks do not supply genetic resources of non-MLS vegetable crops anymore without SMTA. This is a very important change. Availability of genetic resources was, prior to this development, based upon good personal relations with gene bank staff members and counteracts (i.e. multiplication and description) executed by the breeding companies: highly appreciated and necessary counteracts in order to help/facilitate a gene bank organization. Will this situation change because of the implementation of the MLS/SMTA?

I refer to the paper of Anke van den Hurk/Plantum.NL: "Access and use of genetic resources is of vital importance for continuity in vegetable variety development and improvement" Therefore the MLS and its SMTA should function as a tool to facilitate access to genetic resources rather than to complicate it. We recognize, as important advantages of the MLS/SMTA, standard conditions and terms for access and benefit-sharing which will provide legal certainty for both provider and user.

But to formalize access of genetic resources according to the MLS for users (i.e. breeding companies) without (financial) support from the (inter)national authorities to the suppliers (i.e. gene banks) is not consistent. The entire MLS/SMTA will only function effectively in case of well-organized gene banks worldwide.

Frequently, in our contacts with gene banks, Enza Zaden is confronted with deviations from the current MLS/SMTA arrangements, lack of proper organization of the gene bank, poor description of the collection and seed quality problems (either germination and/or contamination).

It is necessary to involve the private sector more in order to improve the MLS/SMTA/ABS set-up and its practical implementation.

* Director Enza Zaden R&D B.V., The Netherlands

Discussion

CHRISTOPH HERRLINGER (BDP GERMANY): I have only a very brief remark regarding the issue of benefit-sharing. You mentioned, I think it was on slide number 10, that you do not agree with the idea of benefit-sharing in the case of the breeders' exemption. I think one should very clearly state that this relates to the monetary benefit-sharing because if we talk about the breeders' exemption, the breeders' exemption as such is already a very important form of benefit-sharing in the sense that the material is made available again. I think that all the breeders who use PVP, and with that the plant breeders' exemption, also engage in other forms of benefit-sharing, for example capacity-building. Do you agree?

JOEP LAMBALK (DIRECTOR ENZA ZADEN R&D B.V.): I agree. The point is that in our discussions within Plantum, especially when you are talking about IPR, be it a patent or plant breeders' rights which is in fact also a form of IPR, what we are really fighting for is that, in the case of plant breeders' rights the material is freely available for everybody, so that there are no specific conditions with respect to the benefit-sharing aspect.

FRANÇOIS BURGAUD (GNIS FRANCE): You said that once you were supposed to pay 50.000 Euros for one accession. I would like to know if it was an accession inside or outside the multilateral system of the International Treaty, and more generally I would like to know if you have encountered the same problem that we have now with field crop gene banks and also with vegetable gene banks. Because of lack of funding, you are saying, more and more gene banks use the concept of "material under development" to ask for payment for their material. In rice, for example, IRRI is more often asking for money for granting access to their material. So I would like to know if you have noticed the same negative evolution in vegetable gene banks.

JOEP LAMBALK (DIRECTOR ENZA ZADEN R&D B.V.): Just to give you an answer to the first question; that was in tomato, so in fact outside. The reason that the gene bank was asking 50.000 Euros had to do with some specific research on that material for which they wanted to be compensated as well. But I think that is often the case. You will probably agree that often material is not completely blank, it always comes with a specific description, and well, the gene bank would like to see benefits for all of it. But it makes things rather complex when we have to compensate for things that the gene banks have done but in fact we did not ask them to do.

BERT VISSER (WAGENINGEN UNIVERSITY, NETHERLANDS): Just by way of a short interruption: I think the beauty of the Multilateral System it that is does not only provide you with material, it also provides you freely with information on the material, which is very important to stress.

ILDEFONSO JIMENEZ (IRRI): Just a comment on the previous comment: as far as I know we only charge shipping costs for accessing material from our gene bank.

BERT VISSER (WAGENINGEN UNIVERSITY, NETHERLANDS): I think your statement is correct, but now you are stating that you only ask shipping costs, if any costs, for material from the gene bank. Yet I think reference was made to material coming from your breeding programs, and I'm not sure whether you could also enlighten us as to the policy of IRRI on breeding material that is under development.

ILDEFONSO JIMENEZ (IRRI): I am not as familiar with the breeding materials in this respect, but I am not aware of any costs other than the shipping costs for the gene bank material.

BERT VISSER (WAGENINGEN UNIVERSITY, NETHERLANDS): I think it is important to make that distinction between breeding materials and gene bank materials. The latter should be freely available - and if not you've got a good case for complaint, especially here at FAO at the International Treaty when it comes to Annex I materials.

ORLANDO DE PONTI (ISF): That was exactly the case: the difference between a basic germplasm from the gene bank and material under development. As far as I have been informed there is a monetary payment if it is material under development, at least in the case of IRRI.

ISABELLE CLÉMENT-NISSOUS (GNIS): To make the link between genetic resources and the presentation this morning on rice and gene markers: is it possible in the near future to have finger printing with genetic resources? When we follow ABS negotiations we see lots of presentations claiming that very soon we will have gene reporting for all the world's biodiversity. My question is: is it possible to do exactly the same for all accessions that we know in breeding material, accessions contained in gene banks and the like?

The question has been referred by the Chair of the session to the final discussion.

IMPLEMENTING THE INTERNATIONAL TREATY AT THE NATIONAL LEVEL: WHAT IS THE IMPACT ON THE SEED SECTOR?

Ms YLVA TILANDER*

The Swedish National Program for Biodiversity in Agriculture, Public Awareness

The launch of strong national programs is one of the priorities in the Global Plan of Action for the Conservation and Sustainable Utilization of Plant Genetic Resources for Food and Agriculture. National programs are the foundation of regional and global efforts in this area and provide a framework in which the International Treaty can be implemented.

The Swedish national program is called the Programme for Diversity of Cultivated Plants (POM). It was decided by the Government in the year 2000 after a proposal from the Board of Agriculture.

The goals of the POM (2010 to 2015) are as follows:

- Conservation and use of plant genetic resources shall contribute to improved food security, sustainable agriculture and maintain biodiversity in Sweden.
- The program shall help our biological cultural heritage come alive.
- Materials that are conserved within the program shall be well documented, and information about the materials shall be available for free.
- The program shall promote international cooperation in the areas of conservation, utilization, access to plant genetic resources and benefit-sharing of the profits arising from their use.

The program has five fields of activity involving different tasks and actors. These fields of activity are conservation, utilization, research and development, training and information, as well as international efforts.

One of the activities in the program up to now has been specific "calls" to the public to report their seeds and material, with the aim of recovering information about forgotten and less-known species. Calls have been issued in eight areas, examples being vegetables and fruits and berries.

This has been a very successful activity and has largely contributed to raising public awareness and interest. Also, it has led to a great deal of new information about varieties that were previously less known – for example peas, where a lot of genetic variability was detected with the help of the public.

The Nordic Regional Approach in the Nordic Genetic Resources Center

The five Nordic countries Denmark, Finland, Iceland, Norway and Sweden – being rather small and to a large extent sharing the same plant genetic material – have for 30 years found it natural, practical and economical to collaborate on one common gene bank. The Nordic Gene Bank was established as an institution under the Nordic Council of Ministers in 1979.

In January 1, 2008, the mandate of this institution was extended to cover Nordic forest genetic resources and Nordic farm animal genetic resources: the Nordic Genetic Resources Center (NordGen) was established. Since January 1, 2009, environmental aspects related to the management of genetic resources have also been integrated in the NordGen mandate.

* Deputy Director, Ministry of Agriculture, Sweden

The NordGen vision is:

"NordGen secures a biological basis for life for the present and for the future"

The four priorities in the strategy 2008 to 2012 are:

- Conservation
- Sustainable use
- Information and networking
- International activities

Twenty-eight thousand accessions are stored in NordGen. The plant material consists of cereals (60 per cent), vegetables (18 per cent), forage crops (16 per cent), root crops, oil plants and pulses (5 per cent) and industrial/medicinal plants (1 per cent).

The Svalbard Seed Vault

The Nordic Gene Bank has been storing a Nordic safety collection in an abandoned coal mine in the permafrost at Svalbard/Spitzbergen for more than 25 years. The experiences gained have been one of the points of departure for the Svalbard International Seed Vault, opened in February 2008.

The Vault provides the most secure storage possible and is available for "black box" storage, according to international agreements. NordGen manages day-to-day operations under an international steering committee.

For what Purposes are the Seeds from the Gene Bank used?

As mentioned, sustainable use is an important priority for NordGen and where we would like to increase emphasis in the years to come.

NordGen has always emphasized the importance of making the material and related information available. The documentation information system SESTO, developed at NordGen, is key in this.

The categories of receivers of material have varied quite a bit over the years. Research use and private persons (or "other" uses) dominate. Use by breeding companies constitutes a smaller share, but it would not surprise me if this share were to increase in the near future, given new needs in response to climate change.

Ongoing efforts to encourage use of the gene bank include discussions on pre-breeding and new collaborations with various stakeholder groups like seed-saver organizations and partners in ornamental plant genetic resources. A new field regarding the cultural history of crop plants has also recently been initiated.

Practical Experience in using the SMTA

The Standard Material Transfer Agreement has been used by NordGen for all transfers since October 1, 2007. Since then 96 SMTAs have been issued covering 2,523 accessions. The material concerned is mostly beans and cereals.

NordGen has decided to use the SMTA (with footnote) regarding both Annex 1 and non-Annex 1 species. Small samples of seed for home use are delivered with a "Hobby MTA".

Experience from the National Seed Industry

The SMTA has only been in use for a short period of time. This is why there are at present only a few records on its use by the national seed industry in Sweden. The breeding companies in Sweden have up to now to a large extent had the required resources in their own gene banks. However, there seems to be a particular interest in disease-resistant genes – related to climate change – and from that perspective there may be a growing interest in using gene bank material in the coming years.

The Nordic countries are small, as are their markets for the plant breeding industry. At the same time climate change contains a particular challenge for our part of the world. Accessions adapted to warmer and rainier summers could be found in other regions. However, normally these are not adapted to the very specific light regime we have in the Nordic countries, with many hours of daylight during summer. Further, it is foreseen that there will be an increased need for disease-resistance genes in the new climate.

Therefore, there is an ongoing discussion on how to meet these challenges. Within the framework of the Nordic Council of Ministers an analysis is presently being elaborated. The analysis includes NordGen, the plant breeding industry, research, other stakeholders as well as polic-makers. Pre-breeding has been identified as a main area where concerted action would be welcome. A public/private partnership is being proposed.

Other proposals are:

- revitalization of Nordic research education on this subject;
- initiatives for collaboration between the Nordic entities engaged in breeding of fruits and berries with the aim of dividing responsibility;
- joint evaluation and testing of vegetable varieties for the Nordic market in order to clarify the adaptation of available varieties to the different climate zones in the Nordic countries;
- a common approach to the testing required in order to receive protection from European plant breeders' rights.

The Nordic Ministers of Agriculture were briefed at a recent Nordic Council of Ministers meeting, but no decisions have yet been taken.

However, it is already possible to reflect on the factors permitting such an open discussion between potential competitors. NordGen has been proposed to administer the new initiative, if decided. My belief is that it has been made possible to formulate such a proposal, as, for decades, the Nordic countries have collaborated in these matters and that has built up a large degree of trust.

Swedish International Support regarding Plant Genetic Resources, including the International Treaty

The Nordic countries have had a very positive experience in collaborating on a regional basis regarding plant genetic resources. In evaluations this approach has repeatedly scored high in efficiency and cost-effectiveness. It has therefore been natural for NordGen and Sweden to encourage this approach in other regions around the world.

Over the years this has resulted in the building-up of several regional networks, receiving considerable support.

Sweden has, in various ways, supported the conceptual development of the International Treaty, both in the negotiations leading up to the decision taken in Madrid 2006 and in the implementation phase.

The International Treaty and its implementation is not easy to grasp. Capacity-building has therefore been a focus for supporting efforts, identified by many Contracting Parties. When Sweden in 2008 decided to make a major contribution to the implementation of the International Treaty it was therefore logical to focus on this area. The Secretary of the International Treaty, in collaboration with Bioversity and FAO, proposed a three-party collaboration in this area, and the Swedish International Development Cooperation Agency, Sida, decided to fund it with 1 million US dollars over two years (spring 2008 to spring 2010).

The FAO/Bioversity capacity-building project focuses on the practical implementation of the Multilateral System of Access and Benefit-Sharing.

The project objective is to develop improved national laws and regulations as well as administrative and information technology arrangements for the operation of the Multilateral System. The project also aims to improve knowledge among national stakeholders of issues underlying the implementation of the Treaty and in particular the Multilateral System.

Concerning activities that have already been or are being implemented, let me present them in two sections.

Regional
The project envisages a series of regional workshops to discuss regional coordination for the implementation of the Multilateral System of Access and Benefit-Sharing (MLS) as well as to pave the way for national assistance. At present, the joint program has almost completed its regional phase and, through its workshops, developed partnerships with recognized regional organizations. To date, the following workshops have been held:

Place	*Date*	*Partnering organization*
Lusaka, Zambia	September 2008	SPGRC
Entebbe, Uganda	March 2009	EAPGREN
Cairo, Egypt	April 2009	AOAD
Kuala Lumpur, Malaysia	May 2009	RECSEA-PGR

Another regional workshop is scheduled to take place in Nadi, Fiji on September 23 and 24 in partnership with the Secretariat of the Pacific Community (SPC).

The regional workshops produced a number of concrete recommendations which the joint program is following up. Examples of such concrete results at the regional level are proposed guidelines including elements of a model law from the Cairo workshop and a regional road map for implementation of the MLS from the Entebbe workshop.

National
Based on proposals for assistance that have been positively appraised by the project steering committee, countries which are receiving direct assistance under the joint program are Kenya, Morocco, Sudan, Zambia, Ecuador, Peru, Malaysia and the Philippines.

Based on available resources, assistance is also being considered for two other interested countries (i.e. Madagascar and Guatemala). Other countries have expressed interest in receiving assistance but the current budget does not allow for meeting these requests at present.

Activities vary based on national needs and priorities. In general, they consist of national capacity-building workshops and studies to review and assess the national legal and administrative frameworks of relevance to the implementation of the MLS. Recommendations for their upgrading are covered, including the description of possible legislative and administrative measures and their main elements or draft primary legislation, executive orders and administrative guidelines for consideration by national authorities.

Conclusion

- The Swedish national program has stimulated great public interest in biodiversity in agriculture as well as collecting material not documented before,
- The SMTA is now in use in the Nordic region, after some need for clarification regarding non-Annex 1 crops (SMTA with footnote is now used for them as well),
- The Nordic regional approach has proven cost effective and has built trust,
- Interest and positive experiences for regional approaches can be found worldwide,
- Climate change poses new challenges, resulting in the need for collaboration. The International Treaty for Plant Genetic Resources for Food and Agriculture provides a good framework in this respect,
- Capacity-building is needed in implementing the International Treaty.

Discussion

TASI (FAO): How are Sweden or the Nordic countries in general thinking of handling the benefit-sharing issue?

YLVA TILANDER (MINISTRY OF AGRICULTURE, SWEDEN): We fully accept and endorse the Multilateral System on Access and Benefit-Sharing of the International Treaty. We agree in principle that a company that has developed material and gets benefit from it will have to send a certain percentage to the Benefit-Sharing Fund. As has been mentioned, there have been separate donations, for instance from Norway, to the Benefit-Sharing Fund, but at this point I am not aware of any more plans in this direction.

BERT VISSER (WAGENINGEN UNIVERSITY, NETHERLANDS): Let me just reiterate in support of what you just said that all Nordic countries, including Sweden, have also accepted the use of the SMTA for non-Annex I crops, as well as Germany and the Netherlands, and many other European countries are preparing to take a similar position.

General Discussion

FRANÇOIS BURGAUD (GNIS): What Bert Visser said in his introduction holds true because in this kind of discussion the seed industry of developing countries from Asia or Africa is not involved. Yet if you ask a breeder in Africa or in Asia if access is important to them they will say "yes", and in a way access is more important for the new seed industries in developing countries than for the old seed industries in Europe.

The second point: I think we may all agree on is the fact that the Multilateral System needs more money, and I think that even the seed industry has to think concretely about the possibility of making voluntary contributions to the Multilateral System. This, however, should not be a pretext for governments not to put any money in the Multilateral System. I think it's important that at the policy forum the day after tomorrow, we as the global seed organizations say to governments: "you have to invest money in genetic resources and in the Multilateral System". We can say that it is of great importance for breeding, and breeding is too important for food security to accept that governments don't invest in it.
Last but not least, we have to pay attention to the fact that the insistence on on-farm management of genetic resources is also often a pretext for governments not to do anything other than that. We all know that you need more than on-farm management today to increase world genetic progress.

LEO MELCHERS (SYNGENTA SEEDS): I would like to respond to a comment from the audience by Plantum with respect to IP protection in plant breeding. I would like to stress the fact that breeders' rights and patent rights are actually different but complementary systems, as well as the fact that both these systems are important to foster innovation in agricultural research. Mr. Niebur, too, made a comment about the importance of both systems this morning. We do not support the Plantum IP position that plant breeders' rights are sufficient in that respect and that patent rights can be ignored or denied. It is really critical to have balanced co-existence of both plant variety protection and a patent rights system in order to stimulate innovation in plant breeding and to address the increasing challenges we are confronted with in agriculture.

ISMAHANE ELOUAFI (CANADIAN FOOD INSPECTION AGENCY): Where do intellectual property or breeders' rights reside for those 600.000 varieties that you have in your MLS?

SHAKEEL BHATTI (ITPGRFA): In fact, perhaps a very general factual description of what the Treaty provides in respect of IPR under Part IV on the Multilateral System: the Treaty provides in its Article 12 that the material in the form received from the Multilateral System, including its genetic parts and components, should not be the subject of IP claims that would restrict further access in the terms of the Multilateral System. There is a second set of provisions under Article 13, that is the benefit-sharing part, which provides that - though there is no explicit reference to IPRs - under commercial benefit-sharing the payment of 1.1 per cent of sales from products incorporating material from the Multilateral System is triggered when that product is not available without restrictions for further breeding, research and training. Those are, very generally speaking, the two main provisions in the Treaty that refer to IPRs, explicitly or implicitly.

BERT VISSER (WAGENINGEN UNIVERSITY, NETHERLANDS): So the Treaty and the MLS accept the reality and in fact IPRs, and a distinction is made between the two major types of IPRs that we have in the sense that voluntary payments are expected, or are hoped for, in the case of plant breeders' rights, whereas mandatory payments are due in the case of patent rights that lead to successful commercialization.

ORLANDO DE PONTI (ISF): The issue of perception has already been mentioned. On the one hand there are people, quite often breeders, who are interested in access, and on the other side there are other people that are interested in benefit-sharing. And my experience over many years is that they are more interested in financial benefit-sharing, in money. So I have a question to the speakers, I make a comparison with what happened in Norway: let's say that I can convince the Government of the Netherlands to do the same, and that they bring to the Funding Strategy 0.1 per cent of the seed sales in my country. Does it mean that as a breeder in my country I am exempted from Article 13 and that I am not obliged to pay the 1.1 per cent, if I ever get into that situation where access is no longer unrestricted?

COSIMA HUFLER (ITPGRFA): No, it does not exempt you, obviously, but you could probably argue with your Government who would make that commitment of 0.1 per cent of the value of seed, that they would probably also take over your charges when it comes to commercialization.

ORLANDO DE PONTI (ISF): If the whole world followed this approach, and if Marcel Bruins is right that the world's turnover of seeds is 36 billion US dollars, it would bring your Funding Strategy 36 million US dollars. That is a nice amount of money, and maybe the administrative load for the industry could be abandoned.

BERT VISSER (WAGENINGEN UNIVERSITY, NETHERLANDS): Further to this discussion, the Secretary of the International Treaty has just reminded me of a resolution that was agreed upon at the last Governing Body of the International Treaty, which foresees that the countries that are members of the Treaty are supposed to develop innovative approaches towards the funding of the implementation of the Treaty. "Innovative approaches" of course is a very general description, but it is certainly also a reference to the one case that we have in practice, which is the Norwegian example of 0.1 per cent of the seed sales being shared with the Treaty for its implementation. But, of course, the Treaty and all those who are trying to implement it are open to any other innovative approaches, including, undoubtedly, voluntary contributions from the private sector.

[Session Summary by B. Visser]

First of all the interdependence of countries, as well as of breeding companies upon each other was mentioned.

It was also mentioned how important access to plant genetic resources is for the future; not only the future for plant breeding, but as an immediate consequence for the future of food security in our world, and I think this shows how important a proper access and benefit-sharing regime is.

The International Treaty is a unique, legally binding instrument that provides a sectorial solution to conservation and also to the utilization of plant genetic resources, and with that access to plant genetic resources.

The core of that International Treaty is the Multilateral System which provides a very transparent ABS regime for the 64 crops in Annex I that come under the Multilateral System. The Multilateral System is operationalized by a Standard Material Transfer Agreement that is increasingly being used; of course it takes some time for such a new instrument to come into use. It's not only used for material that is part of the Multilateral System, but it is also used for many other transfers, and I mentioned the case of Europe where not only a few countries but in fact the entire European network of gene banks has agreed that it will use the SMTA not only for Annex I crops but for all exchanges.

It is important to stress the need to involve the private sector in the implementation of access and benefit-sharing measures, and I think that goes without any further saying.

It is important to stress here also that the material that has been incorporated in the Multilateral System is a source of genetic resources, traits and characteristic of interest to the sector.

Let me summarize by saying that the success of the International Treaty will depend on implementation at the international level and also at regional and national levels, as well as at the level of institutions and companies.

I mentioned already that the Multilateral System is a system of access and benefit-sharing; it tries to realize access, but it can only do so if benefit-sharing is also realized. The Funding Strategy of the International Treaty is the major mechanism to achieve this.

Let me close by saying that we have also seen some contributions on the issue of IPRs this morning and this afternoon, and I am trying to make a link to the access and benefit-sharing agenda: I think we all need more discussion on this issue in order to further clarify how efficient ABS and IP regimes should be and how they should and may impact on the sector.

Session 2. Conclusion, presented by the Chairperson
The importance of plant genetic resources for plant breeding; access and benefit sharing

- Plant breeding and the sustainable use and conservation of genetic resources are interdependent.
- The International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) is a unique and innovative legally binding instrument providing facilitated access to genetic material for plant breeding at the international level
- The Multilateral System (MLS) of the ITPGRFA provides a consistent Access and Benefit-sharing option for plant breeding activities
- The Standard Material Transfer Agreement (SMTA) of the ITPGRFA is a contract between the provider and the recipient that is simple to use and facilitates access to germplasm
- The involvement of the private sector in the design of Access and Benefit-sharing schemes is necessary for a well functioning Access and Benefit-sharing mechanism
- Material in the MLS is a source of genetic traits and characteristics of interest
- The full success of the ITPGRFA and its MLS will depend on local, national and regional implementation, as well as on the availability of funds at the local, national and regional level.

Session 3

PLANT VARIETY PROTECTION

Chairperson: Mr. DOUG WATERHOUSE (AUSTRALIA),
International Union for the Protection of New Varieties of Plants (UPOV)

- **Benefits of plant variety protection**
  Mr. ROLF JÖRDENS, Vice Secretary General, UPOV

- **Key requirements for an effective system of plant variety protection**
  Mr. PETER BUTTON, Technical Director, UPOV

- **Experiences in Kenya**
  Mr. EVANS SIKINYI, Head, Seed Certification and Plant Variety Protection, Kenya Plant Health Inspectorate Service (KEPHIS)

- **Experiences in the Republic of Korea**
  Mr. CHANG HYUN KIM, Director General, Korea Seed & Variety Service (KSVS)

General discussion

Conclusion, presented by the Chairperson

BENEFITS OF PLANT VARIETY PROTECTION

Mr. ROLF JÖRDENS*

Introduction

With regard to "responding to the challenges of a changing world", it can be said that this is the raison d'être of plant breeding. The role of plant breeders is to use germplasm resources to develop new varieties which respond to particular environments and which meet consumer demand. The breeding process must meet the demands of a changing environment (e.g. evolution of disease resistance, development of varieties that perform well in different agroclimatic environments), while responding to evolving consumer demand. For plant breeders, the world is constantly changing. The role of plant variety protection in responding to the challenges of a changing world is to provide a legal framework that encourages plant breeding. The focus of this presentation is to show how an effective system of plant variety protection and UPOV membership has responded to the various demands of a range of countries.

With regard to intellectual property (IP) protection, Article 27.3(b) of the TRIPS Agreement establishes that members of the World Trade Organization may exclude from patentability plants and animals other than microorganisms; however, they must provide for the protection of plant varieties, either by patents or by an effective sui generis system or by any combination thereof.

With regard to patents for plants, the results of a WIPO-UPOV Symposium on intellectual property rights (IPRs) in plant biotechnology, held on October 24, 2003, in Geneva, were clear: progress in plant biotechnology is important for all countries, developed and developing, and requires appropriate protection of IPRs. In this regard, patents and plant breeders' rights are both needed and often combined in protection and promotion of plant biotechnology. However, this paper will focus on plant variety protection.

Plant breeding requires considerable investment in time and resources. However, it can be relatively quick and easy to reproduce new varieties. Without the ability to cover their investment, breeders will be unable to invest in breeding. By making the reproduction and commercial exploitation of varieties subject to the breeder's authorization, the UPOV system of plant variety protection provides the breeder with the possibility to recover investment in plant breeding work.

Many countries, including developing countries and countries in transition to a market economy, are considering the introduction of a system for the protection of new varieties of plants (PVP system). Most countries which have already introduced a PVP system have chosen to base their system on the International Convention for the Protection of New Varieties of Plants (UPOV Convention) in order to provide an effective, internationally recognized system (see Annex).

With respect to the purpose of a PVP system, UPOV clarifies that its mission is "To provide and promote an effective system of plant variety protection, with the aim of encouraging the development of new varieties of plants, for the benefit of society". Thus, the UPOV system of PVP is designed to encourage innovation in the field of plant breeding, in order to promote the development of new varieties that will benefit society. Society in this context means all society, and all members of society are consumers in some way. However, it is also recognized that farmers and growers are the deliverers of the benefits of new varieties to society and are also the first beneficiaries of new varieties which offer improved income through improved yields, improved quality and the opening-up of new market possibilities.

* Vice Secretary General, UPOV

As a means of providing countries considering the introduction of a PVP system with information on the benefits they might expect, in 2005, UPOV published the "UPOV Report on the Impact of Plant Variety Protection" ("Impact Study") (*http://www.upov.int/en/publications/impact.html*). That report was based on the work of a UPOV Ad hoc Working Group to Study the Impact of Plant Variety Protection, which included members from all the countries forming the basis of the Impact Study: Argentina, China, Kenya, Poland and the Republic of Korea (see Section III of the Report "Reports on Studies Conducted in Individual Countries"). The basis of the Impact Study and some of the key findings are summarized in the following section. The findings of the studies in Kenya and the Republic of Korea are reported in separate papers.

UPOV Report on the Impact of Plant Variety Protection ("Impact Study")

In relation to the impact which might be expected from an effective PVP system, it is considered important to recognize that the positive effects of a PVP system may be realized in the form of an incentive to stimulate new breeders and new breeding work and/or providing a basis for more effective breeding work at the domestic level. These positive effects could relate equally to the private breeding sector, the public breeding sector or to partnerships between the two. However, whilst recognizing that such an impact is of critical importance, it is also recognized that an effective PVP system can also provide important benefits in an international context by removing barriers to trade in varieties, thereby increasing domestic and international market scope. In short, breeders are unlikely to release valuable varieties into a country without adequate protection. With access to such valuable foreign-bred varieties, domestic growers and producers have more scope to improve their production and also have more scope to export their products. It is also recalled that, as a consequence of the breeder's exemption in the UPOV Convention, domestic breeders also gain access to valuable varieties for use in their breeding programs. This international aspect is an important means of technology transfer and effective utilization of genetic resources. Therefore, the Impact Study considered the development of the UPOV system at the international level as well as at individual, country level.

This paper revisits two of the main sections of the Impact Study: Development of the UPOV System of Plant Variety Protection and the "Reports on Studies Conducted in Individual Countries" with updated information.

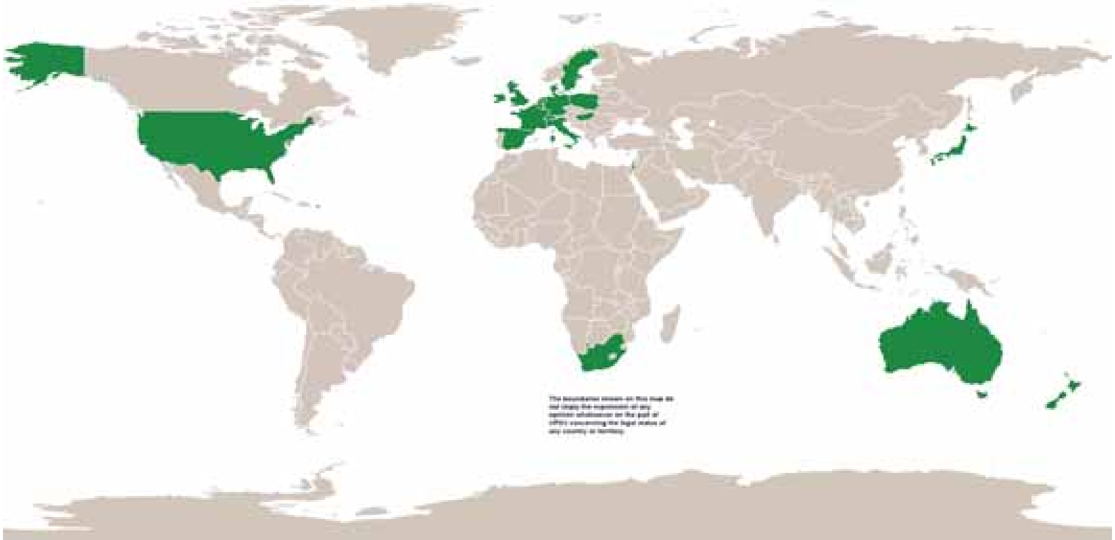
Development of the UPOV System of Plant Variety Protection

UPOV Membership

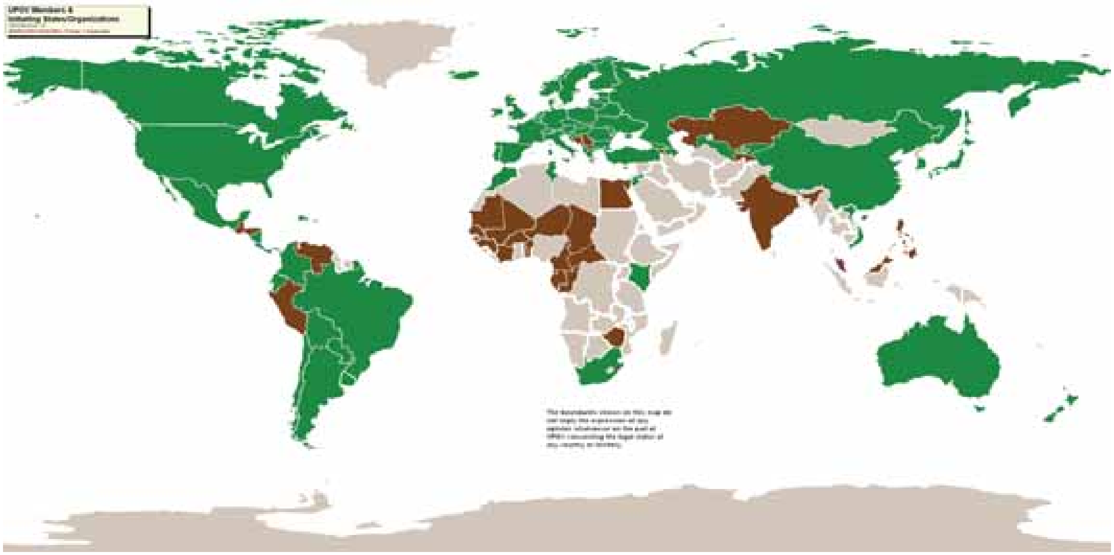
The UPOV Convention was adopted in 1961 as a result of the Diplomatic Conferences held in Paris in 1957 and 1961. The UPOV Convention entered into force in 1968 with the ratification of Germany, the Netherlands and the United Kingdom. The UPOV Convention was amended in 1972, 1978 and 1991. As of September 8, 2009, UPOV had 67 members of which 43 were bound by the 1991 Act of the Convention. UPOV, which continues to be the only internationally harmonized, effective sui generis system of plant variety protection, is continuing to expand. As of September 8, 2009, 17 States (initiating States) and one international organization (initiating organization) had initiated with the Council of UPOV the procedure for becoming UPOV members (see Annex) and another 45 States had been in contact with the Office of the Union for assistance in the development of legislation on plant variety protection.

Fig. 1 illustrates how UPOV has expanded since 1990 to cover most important agricultural producers and many countries from the developing world.

Fig. 1 Members of UPOV (shown in green): 1990



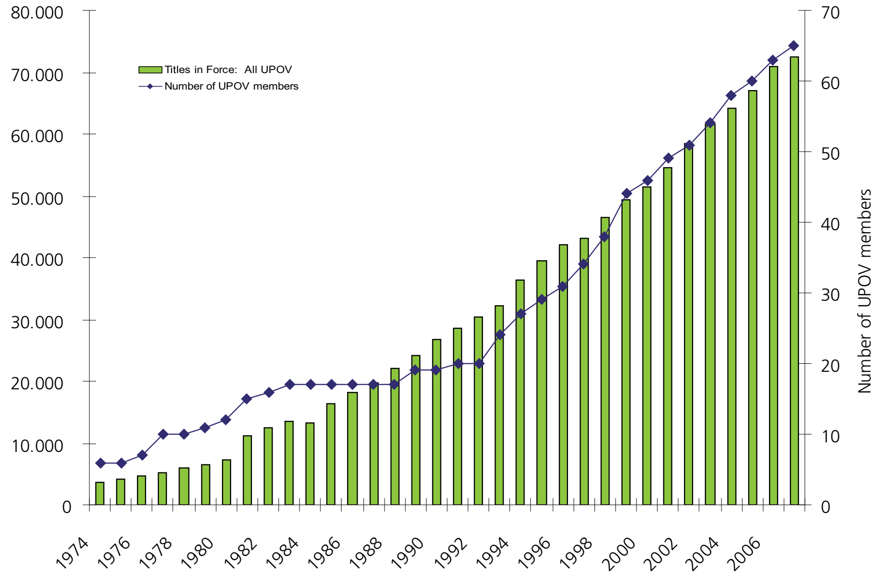
Members of UPOV (shown in dark green) and initiating States and organizations (shown in brown): September 2009



The key to an effective PVP system is to provide incentives to breeders to develop new varieties and to avoid the absence of suitable protection being a barrier to the availability of those varieties. With regard to assessing the overall impact of an effective PVP system from a global viewpoint, it is, therefore, reasonable to look at the number of new varieties. A direct measure of the number of new varieties is provided by the number of applications for protection (applications) and the number of titles of protection granted to new varieties of plants (titles). The number of applications and titles are meaningful measures of the impact of PVP, since they indicate new varieties which have potential importance within the territory concerned. It is recognized that, in a market economy, the value of a variety is ultimately determined by whether it is commercially successful. Therefore, the fact that, in general, breeders do not pursue protection on varieties which are unlikely to be successful or where protection is not important, would seem to offer further confirmation that the number of applications and titles are good indicators of the benefits of a PVP system.

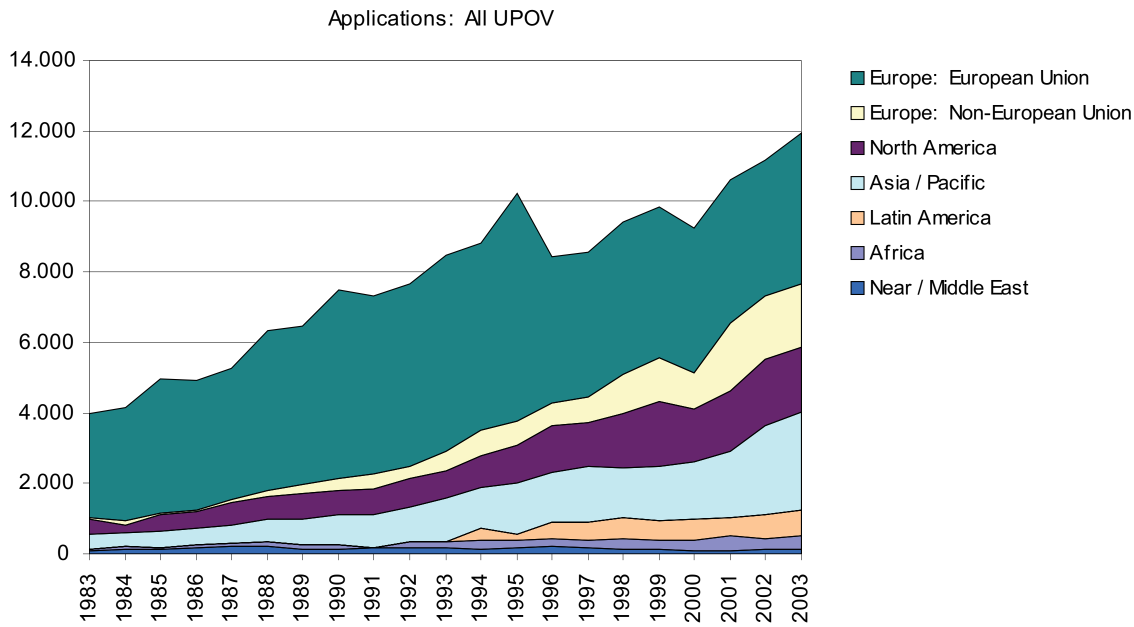
Thus, an illustration of the overall impact of the UPOV system is provided by the number of titles of protection in force within UPOV. Fig. 2 shows the number of titles in force with UPOV members and the Community Plant Variety Office of the European Community (CPVO) for the period 1974 to 2007. The CPVO is a European Community agency which manages a system of plant variety rights, in conformity with the 1991 Act of the UPOV Convention, covering the member States of the European Community (Community PVP system). The CPVO data have been included since their introduction in 1995 because, whilst the European Community only became a member of UPOV in 2005, most of the member States were members of UPOV in 1995.

Fig. 2 Titles in Force: All UPOV and CPVO



With the expansion of UPOV, the importance of PVP has grown in different regions, as illustrated by the number of applications presented in Fig. 3. The growth in the UPOV membership of countries from Asia, Latin America and countries in transition to a market economy between 1983 and 2003 is reflected in their growing use of the PVP system.

Fig. 3 Applications: All UPOV and CPVO: by region



Expanding the Protection across Plant Genera and Species

The UPOV Convention recognizes that it is important to encourage breeding in all plant genera and species and not to attempt to pre-determine for which genera and species breeding would, or might, be beneficial. In 1975, protection had been granted to varieties of approximately 500 plant genera or species, growing to around 900 by 1985 and over 1,300 by 1995. It is estimated that protection had been sought for varieties of more than 2,500 genera or species by 2008.

Expansion of UPOV: a Benefit for New and Old UPOV Members

The following section observes the way in which the expansion of UPOV benefits older and newer UPOV members. To look at the situation from the perspective of oldest and newest members, the section categorizes countries into those which were UPOV members by 1992 (older members) and those which became members at a later date (newer members). The year 1992 was chosen because, as can be seen in Fig. 2, that year signified the end of a period of fairly stable membership and the start of a continuous expansion in membership.

Older UPOV Members: the European Community Countries

Fig. 4 demonstrates how the European Community has offered an increasingly important market for breeders from outside the European Community. On the other hand, Fig, 5, which analyzes the number of applications made by residents of 10 European Community countries (Belgium, Denmark, France, Germany, Ireland, Italy, Netherlands, Spain, Sweden and United Kingdom: those which were UPOV members by 1992) with UPOV members other than those belonging to the European Community countries, demonstrates that the expansion of UPOV has presented increased opportunities for breeders based in the European Community.

Fig. 4 CPVO Applications

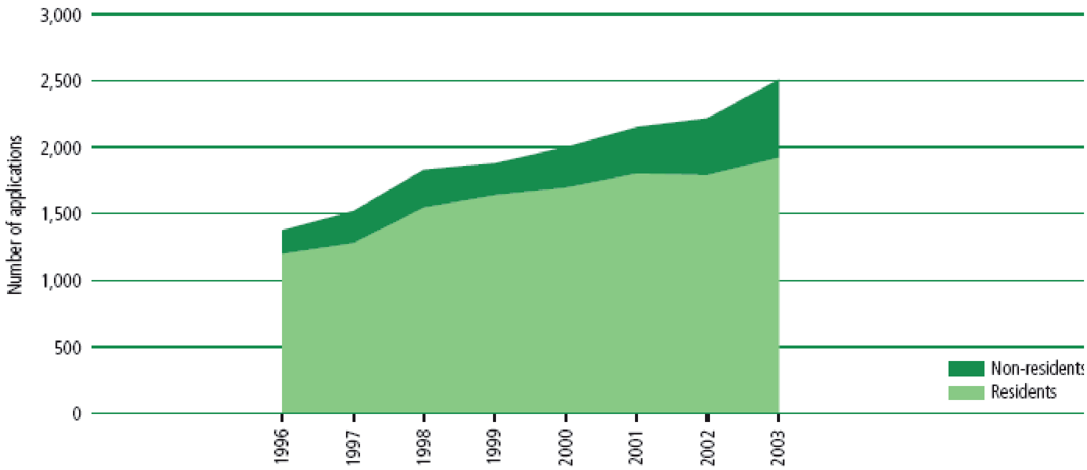
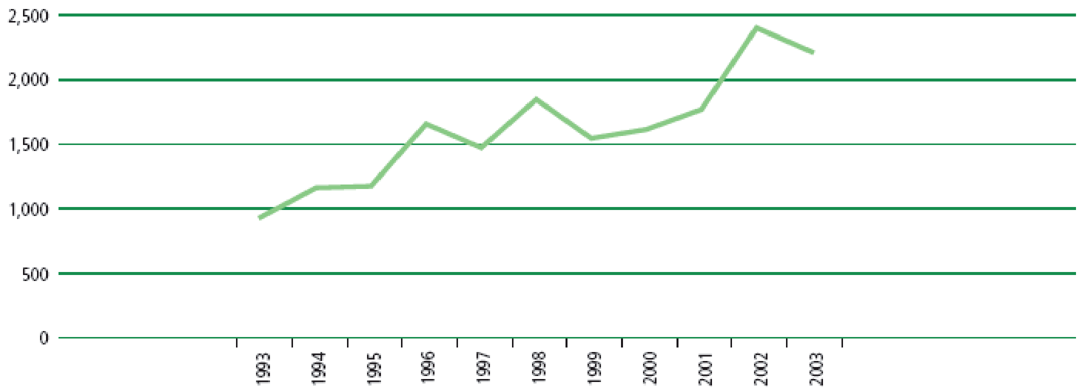


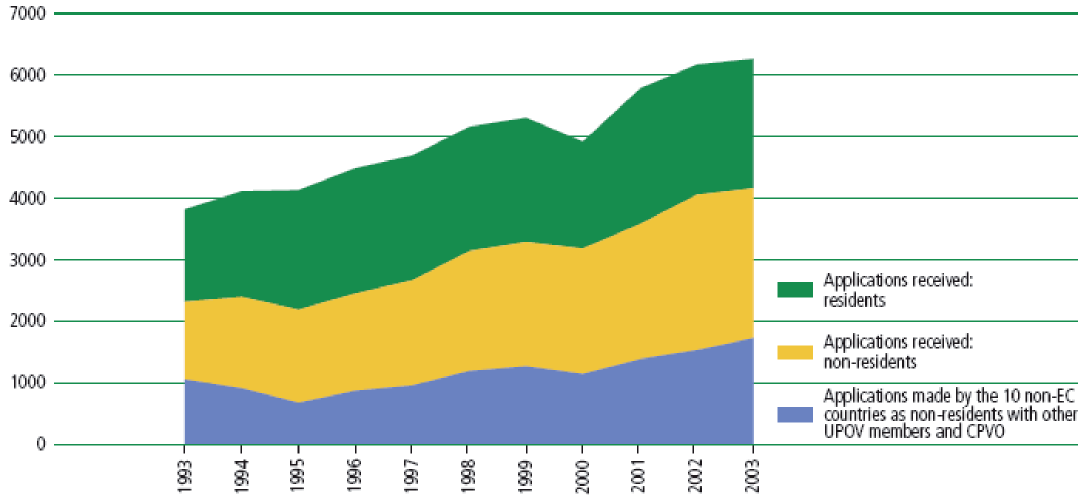
Fig. 5 Applications by 10 European Community Countries (UPOV members by 1992) as Non-Residents outside the European Community



Older UPOV Members: Other Countries

An overview of developments with regard to the other 10 older UPOV members (Australia, Canada, Hungary, Israel, Japan, New Zealand, Poland, South Africa, Switzerland, United States of America) which were UPOV members by 1992, is provided in Fig. 6. In a similar way to developments for the European Community, that group of countries has also seen an increase in the number of applications received, particularly from non-residents and also shows that the number of applications made by their breeders in other territories has also increased.

Fig. 6 Ten Non-EC Countries (UPOV Members by 1992)

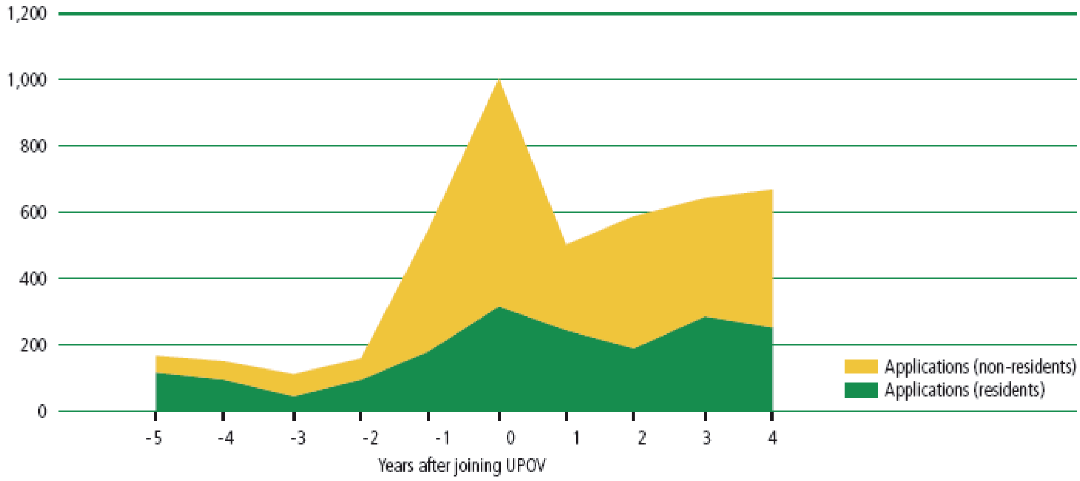


Newer UPOV Members

With regard to countries which have joined UPOV more recently, it is already possible to consider impacts which became apparent immediately on joining UPOV, or soon thereafter. The majority of countries which joined UPOV between 1993 and 2000 and, therefore, for which it has been possible to obtain useful data, were countries in transition to a market economy (Bulgaria, Czech Republic, Estonia, Kyrgyzstan, Republic of Moldova, Russian Federation, Slovakia, Slovenia and Ukraine) or were Latin American countries (Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Mexico, Panama, Paraguay and Uruguay). An overview of developments in those two categories is provided below. Of the remaining seven countries which joined UPOV between 1993 and 2000 (Austria, China, Finland, Kenya, Norway, Portugal and Trinidad and Tobago), China and Kenya were the subject of individual country profiles in the Impact Study.

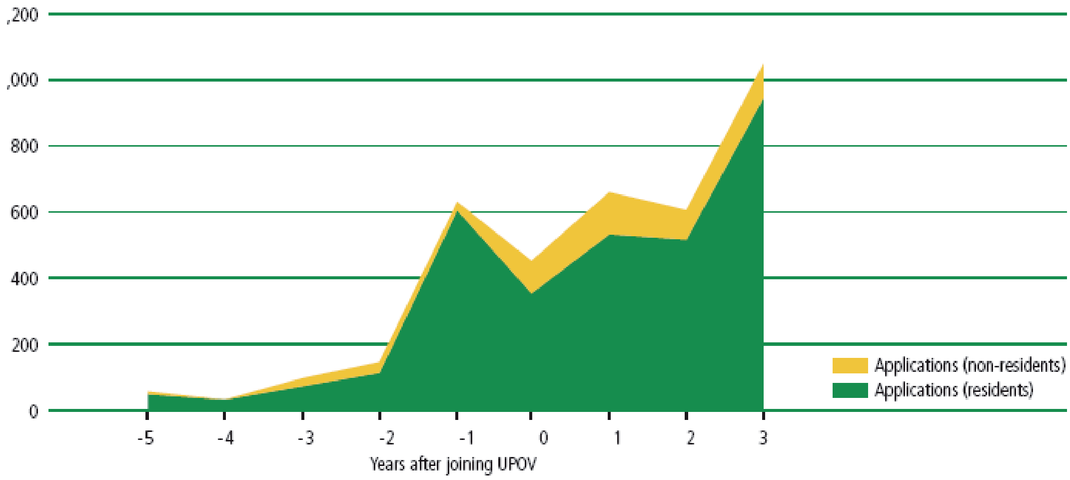
An overview summary of the 10 Latin American countries which joined UPOV between 1993 and 2000 is provided in Fig. 7. It is apparent that joining UPOV was characterized by a substantial demand for variety protection and, in particular, a large influx of foreign varieties (applications by non-residents). A high proportion of non-resident applications relate to ornamental varieties. In that regard, it can be observed that access to such varieties is important to enable producers in those countries to meet the demands of the global market place and indicates how the lack of an effective and internationally recognized PVP system can act as a barrier to global trade.

Fig. 7 Latin America Countries acceding to UPOV between 1994 and 2000



An overview summary of the countries in transition to a market economy which joined UPOV between 1993 and 2000 is provided in Fig. 8. It is apparent that joining UPOV was accompanied by a substantial demand for variety protection, with the majority of applications made by domestic breeders.

Fig. 8 Countries in Transition to a Market Economy acceding to UPOV between 1993 and 2000



The results demonstrate that joining UPOV was accompanied by a strong demand for protection of new varieties of plants, both in Latin American countries and countries in transition to a market economy. The nature of the demand differed between the two sets of countries, with a particularly high demand for ornamental varieties from non-resident breeders in Latin America, in contrast to a higher demand from resident breeders in countries in transition to a market economy. This picture highlights the fact that an effective PVP system responds to the circumstances in the territory concerned and provides benefits where these can be obtained. The individual country reports illustrate further the different ways in which the benefits may be manifested.

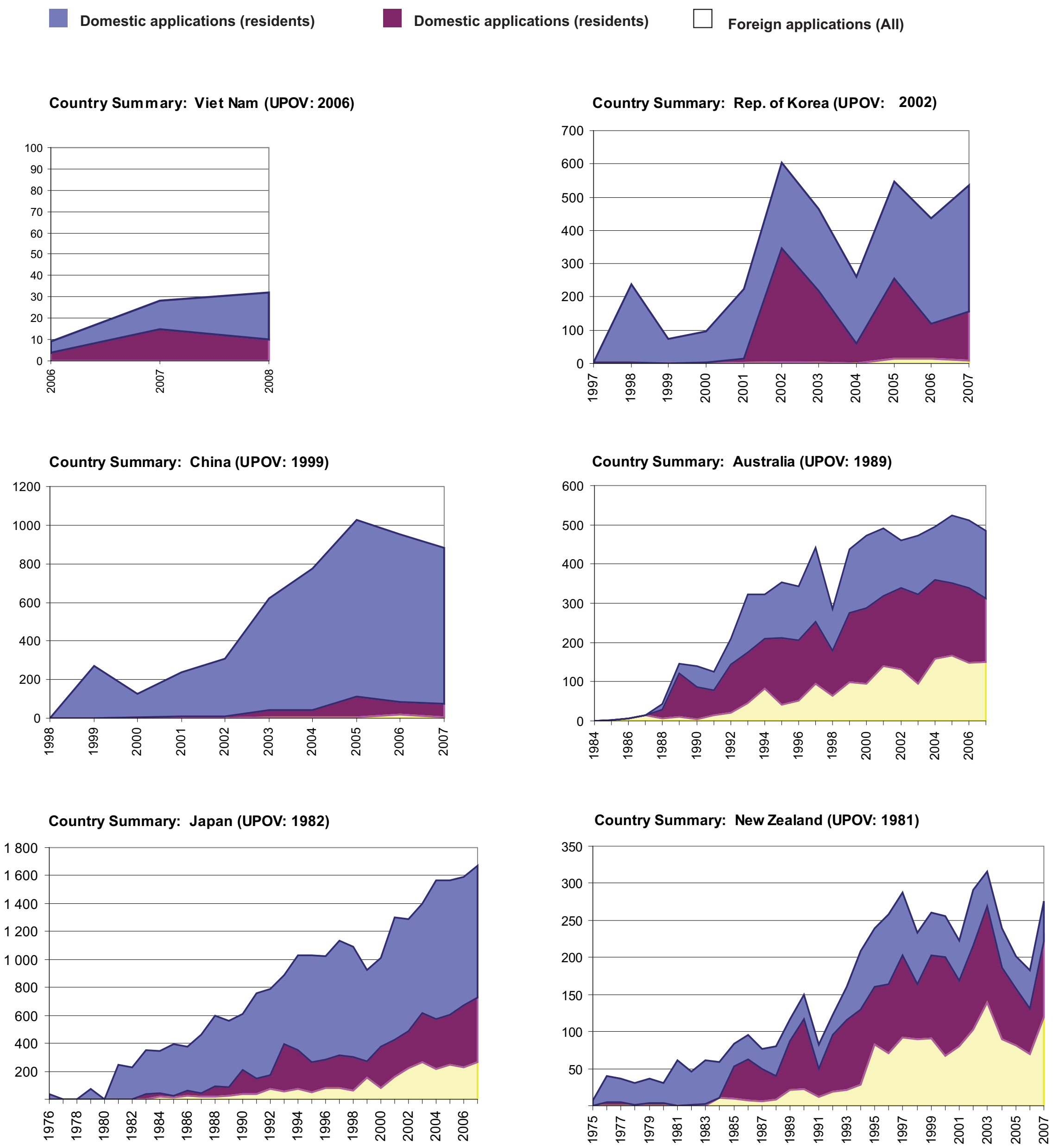
Evolution of Use of Plant Variety Protection

The development of plant variety protection in the Asia Pacific region provides an opportunity to observe the evolution of use of the plant variety protection by breeders over time.

The graphs in Fig. 9 are presented in the order in which those countries became UPOV members: New Zealand (1981), Japan (1982), Australia (1989), China (1999), Republic of Korea (2002) and Viet Nam (2006). No applications have yet been received in Singapore.

In the case of China, Republic of Korea and Viet Nam, which are new UPOV members, it is possible to see that the first use of the system is by residents for domestic applications. Thereafter, it is possible to see that applications from non-residents follow and increase with time. Japan has been a member since 1980 and it is possible to see that same pattern: the first impact is of domestic Japanese breeders making use of the system and, thereafter, applications by non-residents (foreign breeders). The next step, which can be seen in the graphs for Australia, Japan and New Zealand, is that breeders from those countries start to make applications in other UPOV member countries (foreign applications). In the case of China and the Republic of Korea, it can be seen that this stage has also been reached.

Fig. 9 Evolution of Plant Variety Protection in Asia Pacific Region



Reports on Studies Conducted in Individual Countries

It is apparent that the impact of PVP will vary country-by-country and crop-by-crop. Accordingly, although substantial benefits have been seen across the range of UPOV members and, in particular, in each of the countries in this study, the results and conclusions of the study need to be seen in the context of the individual situations. The Impact Study provides information on individual country studies in Argentina, China, Kenya, Poland and the Republic of Korea. The results found in Kenya and the Republic of Korea are presented in separate papers at this Conference.

The Impact Study produced a number of findings concerning the impact of plant variety protection, which might be summarized as follows:

(a) Breeding activity and structure of the breeding industry

The introduction of the UPOV system was associated with increased breeding activity and with the encouragement of new types of breeders, including private breeders, researchers and farmerbreeders. The introduction of PVP was also associated with the development of partnerships, including public-private cooperation.

(b) Improved varieties

Individual country reports in the Impact Study confirmed that the introduction of plant variety protection was associated with the development of new, protected varieties that provided improvements for farmers, growers, industry and consumers.

(c) Increased number of new varieties

The Impact Study provided information on how the number of new varieties increased after the introduction of plant variety protection. It was also demonstrated that membership of UPOV was associated with an increase in the number of varieties introduced by foreign breeders, particularly in the ornamental sector.

(d) Development of international markets

One of the benefits of plant variety protection is to encourage the development of new, improved plant varieties that lead to improved competitiveness in foreign markets.

(e) Enhanced access to foreign germplasm

In addition to providing improved competitiveness for farmers, growers and industry, access to foreign plant varieties is an important form of technology transfer that can also lead to enhanced domestic breeding programs as a result of the breeders' exemption.

Annex 1 Members of UPOV as of September 8, 2009 (67)

Chile[2]
China[2]
Colombia[2]
Costa Rica[3]
Croatia[3]
Czech Republic[3]
Denmark[3]
Dominican Republic[3]
Ecuador[2]
Estonia[3]
European Community[3,4]
Finland[3]
France[2]
Georgia[3]
Germany[3]
Hungary[3]
Iceland[3]
Ireland[2]
Israel[3]
Italy[2]
Japan[3]
Jordan[3]
Kenya2
Kyrgyzstan[3]
Latvia[3]
Lithuania[3]
Mexico2
Morocco[3]
Netherlands[3]
New Zealand[2]
Nicaragua[2]
Norway[2]
Panama[2]
Paraguay[2]
Poland[3]
Portugal[2]
Republic of Korea[3]
Republic of Moldova[3]
Romania[3]
Russian Federation[3]
Singapore[3]
Slovakia[3, 5]
Slovenia3
South Africa[2]
Spain[3]
Sweden[3]
Switzerland[3]
Trinidad and Tobago[2]
Tunisia[3]
Turkey[3]
Ukraine[3]
United Kingdom[3]
United States of America[3]
Uruguay[2]
Uzbekistan[3]
Viet Nam[3]

(Total 67)

1 1961 Convention as amended by the Additional Act of 1972 is the latest Act by which one State is bound.
2 1978 Act is the latest Act by which 22 States are bound.
3 1991 Act is the latest Act by which 43 States and one organization are bound.
4 Operates a (supranational) Community plant variety rights system which covers the territory of its 27 members.
5 Slovakia will become bound by the 1991 Act on June 12, 2009.

Annex 2 States (17) or Organizations (1) which have Initiated with the Council of UPOV the Procedure for Becoming Members of the Union

Armenia, Bosnia and Herzegovina, Egypt, Guatemala, Honduras, India, Kazakhstan, Malaysia, Mauritius, Montenegro, Peru, Philippines, Serbia, Tajikistan, The former Yugoslav Republic of Macedonia, Venezuela, Zimbabwe, as well as the African Intellectual Property Organization (Benin, Burkina Faso, Cameroon, Central African Republic, Chad, Congo, Côte d'Ivoire, Equatorial Guinea, Gabon, Guinea, Guinea Bissau, Mali, Mauritania, Niger, Senegal, Togo (16)).

Annex 3 Other States which have been in Contact with the Office of the Union for Assistance in the Development of Legislation on Plant Variety Protection (45)

Afghanistan, Algeria, Bahrain, Bangladesh, Barbados, Burundi, Cambodia, Congo (Democratic Republic of), Cuba, Cyprus, Djibouti, Dominica, El Salvador, Fiji, Ghana, Greece, Guyana, Indonesia, Iraq, Islamic Republic of Iran, Jamaica, Lao People's Democratic Republic, Lebanon, Libyan Arab Jamahiriya, Madagascar, Malawi, Mongolia, Myanmar, Nepal, Oman, Pakistan, Saudi Arabia, Seychelles, Sri Lanka, Sudan, Suriname, Syrian Arab Republic, Thailand, Tonga, Turkmenistan, Uganda, United Arab Emirates, United Republic of Tanzania, Yemen, Zambia.

Discussion

MR. HOSEA SITIENEI (KENYA SEED COMPANY LTD, KENYA): My question is about the definition of breeder. You have rightly observed that plant breeding is long and expensive and, in most cases, it is the seed companies, universities or national agricultural research institutions that invest a lot of money and the resources in breeding work. So, in your own definition, who is the breeder? Is it the employee who does the work or the company that invests the resources and the time?

ROLF JÖRDENS: The UPOV definition of breeder is the person who bred or discovered and developed a variety, so that can be a natural or a legal person; it is then a matter for national legislation or contracts between the employer and the employee to determine who is entitled to ask for protection. That is not a matter which is regulated by the UPOV Convention in detail. It is a matter for private or national law - arrangements between the employer and the employee.

KEY REQUIREMENTS FOR AN EFFECTIVE SYSTEM OF PLANT VARIETY PROTECTION

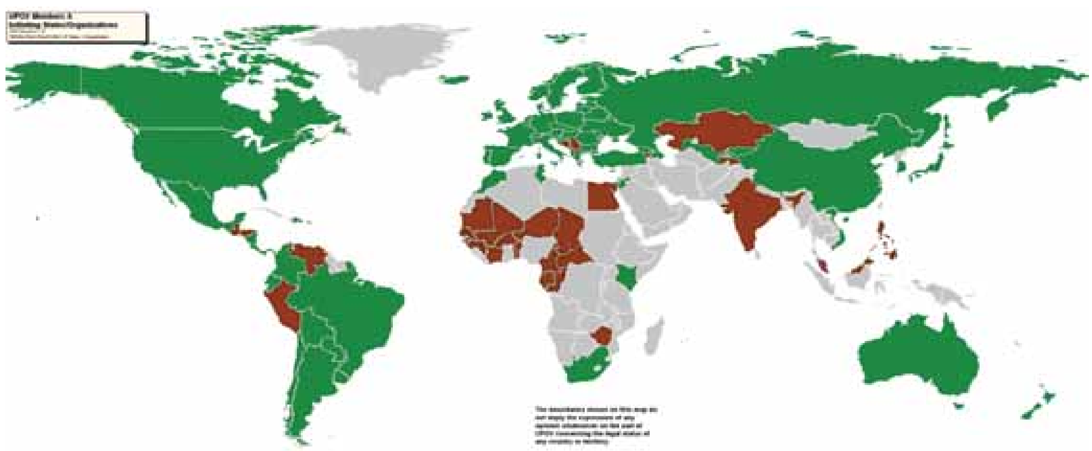
Mr. PETER BUTTON*

Global Perspective

The role of plant variety protection in responding to the challenges of a changing world is to provide a legal framework and system that encourages plant breeding. The presentation "Benefits of Plant Variety Protection", by Mr. Rolf Jördens, demonstrated how an effective system of plant variety protection and UPOV membership has responded to the various demands of a range of countries. It was explained that many countries, including developing countries and countries in transition to a market economy, are considering the introduction of a system for the protection of new varieties of plants (PVP system). Most countries which have already introduced a PVP system have chosen to base their system on the International Convention for the Protection of New Varieties of Plants (UPOV Convention) in order to provide an effective, internationally recognized system (see Fig. 1). Therefore, this presentation will focus on the UPOV system of plant variety protection and will highlight some of the key requirements that are considered important by UPOV to provide an effective legal framework and system. In addition, consideration will be given to the relationship between plant variety protection and other systems that may impact on the development of new plant varieties.

In this paper, reference to the UPOV Convention concerns the 1991 Act of the UPOV Convention.

Fig. 1 Members of UPOV (green) and Initiating States and Organizations (brown)



Selected Provisions of the UPOV Convention

(a) Breeders and Varieties

Breeder

The person who can apply for plant variety protection by means of a "breeder's right" is the person who breeds a new variety i.e., the "breeder". The definition of "breeder" is important because it identifies who is entitled to apply for, and, if the conditions are fulfilled, obtain, a breeder's right. Article 1(iv) of the 1991 Act of the UPOV Convention defines a breeder as:

* Technical Director, UPOV

- "the person who bred, or discovered and developed, a variety,
- the person who is the employer of the aforementioned person or who has commissioned the latter's work, where the laws of the relevant Contracting Party so provide, or
- the successor in title of the first or second aforementioned person, as the case may be."

It is important to note that the concept of "person" embraces both physical persons and legal persons (i.e. companies). The breeder might be, for example, an amateur gardener, a farmer, a scientist, a plant-breeding institute or an enterprise specialized in plant breeding.

The plant-breeding techniques used can range from traditional breeding techniques, such as crossing and selection, through to new technologies, such as genetic engineering. The UPOV Convention makes no restrictions in this regard.

Discoveries can be the initial step in the process of breeding a variety. However, the phrase "the person who bred, or discovered and developed, …" means that a mere discovery or find would not entitle the person to protection. Development of the variety by the breeder is necessary for a breeder to be entitled to obtain protection.

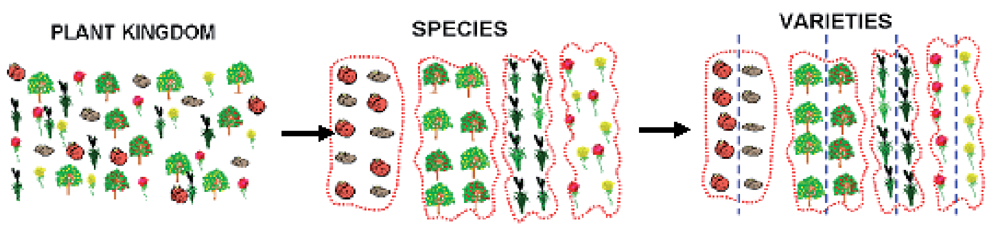
Only the breeder as defined in Article 1(iv) of the 1991 Act of the UPOV Convention is entitled to be granted a breeder's right. The 1991 Act of the UPOV Convention provides, under its Article 21(1)(iii), that "[e]ach Contracting Party shall declare a breeder's right granted by it null and void when it is established […] (iii) that the breeder's right has been granted to a person who is not entitled to it, unless it is transferred to the person who is so entitled."

Variety

A variety is the object of protection, which is defined as follows in Article 1(vi) of the 1991 Act of the UPOV Convention:

"variety means a plant grouping within a single botanical taxon of the lowest known rank, which grouping, irrespective of whether the conditions for the grant of a breeder's right are fully met, can be

- defined by the expression of the characteristics resulting from a given genotype or combination of genotypes,
- distinguished from any other plant grouping by the expression of at least one of the said characteristics, and
- considered as a unit with regard to its suitability for being propagated unchanged."



(b) Conditions of Protection

The UPOV Convention (Article 5) establishes distinctness, uniformity and stability (DUS) as criteria to be satisfied for the protection of a variety.

Distinctness

A variety is deemed to be distinct if it is clearly distinguishable from any other variety whose existence is a matter of common knowledge ("variety of common knowledge") at the time of the filing of the application. The term "variety of common knowledge" is not restricted to protected varieties, i.e. to be protectable, a variety must be distinct from all varieties of common knowledge. Furthermore, "common knowledge" is not restricted to national or geographical borders.

Uniformity

A variety is deemed to be uniform if, subject to the variation that may be expected from the particular features of its propagation, it is sufficiently uniform in its relevant characteristics. This notion of uniformity ensures that the variety can be defined as far as it is necessary for the purpose of protection. This is indicated by the notion of sufficiently uniform, i.e., the criterion for uniformity does not seek absolute uniformity. The UPOV Convention links the uniformity requirement for a variety to the particular features of its propagation. This means that the level of uniformity required for truly self-pollinated varieties, mainly self-pollinated varieties, inbred lines of hybrid varieties, vegetatively propagated varieties, cross-pollinated varieties, mainly cross-pollinated varieties, synthetic varieties and hybrid varieties will, in general, be different. Furthermore, it relates only to the characteristics which are relevant for the protection of the variety.

Stability

A variety is deemed to be stable if its relevant characteristics remain unchanged after repeated propagation or, in the case of a particular cycle of propagation, at the end of each such cycle. As with the uniformity requirement, the criterion for stability has been developed to establish the identity of the variety as the subject matter of protection. Thus, the criterion for stability relates only to the relevant characteristics of a variety.

The two other criteria that a variety must fulfill in order to be protected are: novelty, i.e. the variety must be "new" in the sense that it must not have been sold or disposed of to others during a specified period prior to the filing date of the application, and the variety must be given a suitable denomination. The grant of protection must not be subject to any further conditions, provided that the applicant complies with all the formalities and pays the required fees (Article 5).

(c) Breeder's Right

Duration of Protection

The minimum period of protection (see Article 19) is 20 years from the date of grant of the breeder's right, or 25 years in the case of trees and vines, which is designed to ensure an adequate incentive for the long-term investment that is necessary in plant breeding.

Scope of the Breeder's Right: Material Covered

The plant breeder's right means that the authorization of the breeder of a protected variety (titleholder) is required for certain acts (see Article 14(1)(a) of the 1991 Act of the UPOV Convention). It should, however, be emphasized that the breeder's right does not give a breeder the right to grow or commercialize the variety. The protection of a variety is independent of the measures regulating the production, certification and marketing of material of varieties. Irrespective of whether a variety is protected or not, there may be provisions of legislation to be met before a variety can be released onto the market; for example, environmental legislation (e.g., concerning the release of genetically modified varieties) and/or variety registration requirements involving a minimum level of agronomic performance (e.g., yield, disease-resistance).

The acts which require the authorization of the breeder of a protected variety with respect to propagating material (e.g., seed, bulbs, tubers, cuttings, etc.), are as follows:

- Production or reproduction (multiplication)
- Conditioning for the purpose of propagation
- Offering for sale
- Selling or other marketing
- Exporting
- Importing
- Stocking for any of the above purposes

The use of propagating material without the authorization of the titleholder triggers an extension of the breeder's right to the harvested material obtained from that propagating material (i.e. the unauthorized propagating material) of the protected variety. The UPOV Convention, in its Article 14(2), provides the breeder with a right concerning the harvested material as follows:

The breeder's right extends to harvested material,
- IF the material is obtained through the unauthorized use of propagating material, and
- IF the breeder has not had reasonable opportunity to exercise his right in relation to the propagating material.

In addition, Article 14(3) of the UPOV Convention contains an optional provision which allows members of the Union to extend the scope of the breeder's right to products made directly from harvested material, where this has been obtained through the unauthorized use of harvested material of the protected variety which has itself been obtained from unauthorized propagating material, unless the breeder has had reasonable opportunity to exercise his right in relation to the harvested material.

Scope of the Breeder's Right: Varieties Covered

In addition to the protected variety itself, the scope of breeder's right also applies to the following varieties as stated in Article 14.5 of the 1991 Act of the UPOV Convention (link to Article14.5):

- varieties which are not clearly distinguishable from the protected variety;
- varieties whose production requires repeated use of the protected variety.
  This provision covers, in particular, varieties which are used to produce hybrid varieties.
- essentially derived varieties.
  The purpose of the provision on essentially derived varieties (EDVs) (see Article 14(5)) is to ensure that the Convention encourages sustainable plant breeding development. The UPOV Convention lists some ways in which an essentially derived variety may be obtained: "Essentially derived varieties may be obtained for example by the selection of a natural or induced mutant, or of a somaclonal variant, the selection of a variant individual from plants of the initial variety, backcrossing, or transformation by genetic engineering.".

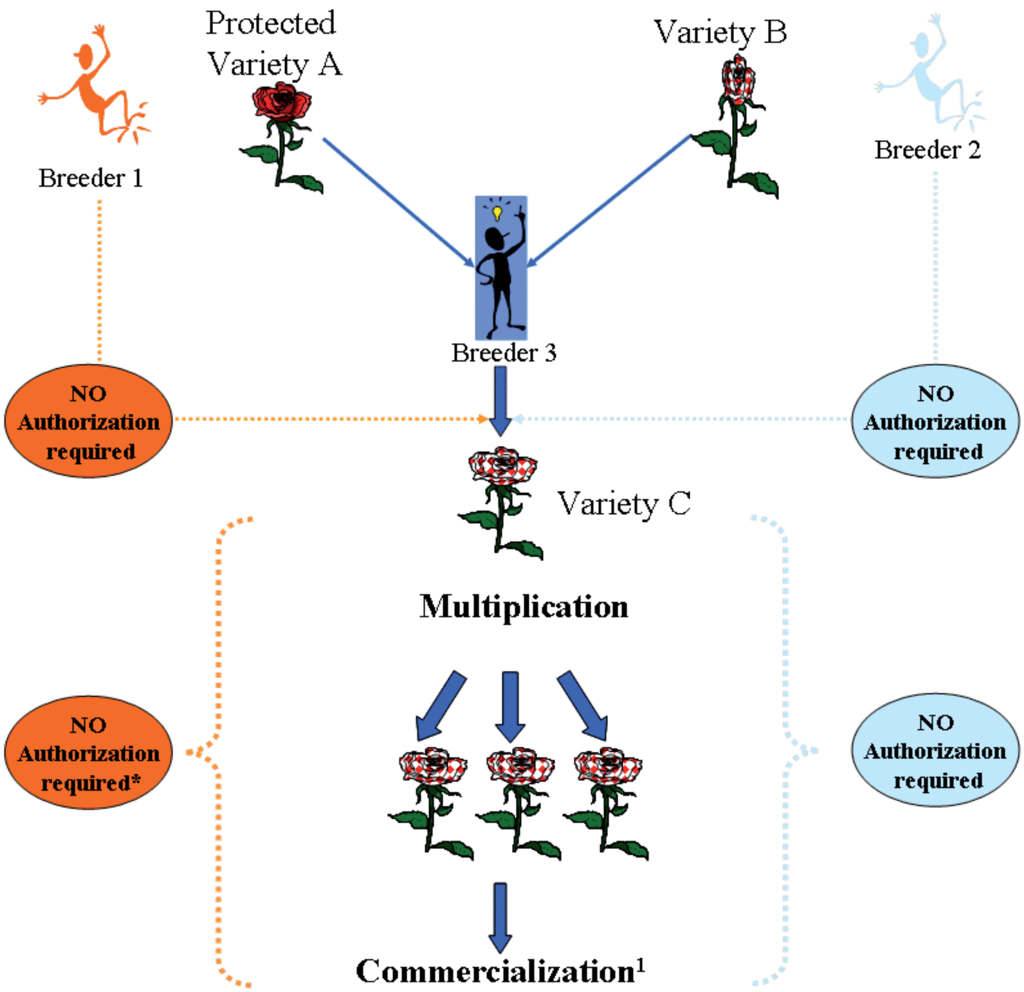
(d) Exceptions to the Breeder's Right

The UPOV Convention establishes compulsory and optional exceptions.

Compulsory Exceptions

- **Acts done privately and for non-commercial purposes.** For example, the propagation of a variety by a farmer exclusively for the production of a food crop to be consumed entirely by that farmer and the dependents of the farmer living on that holding, may be considered to fall within the meaning of acts done privately and for non-commercial purposes. Therefore, activities, including for example "subsistence farming", where these constitute acts done privately and for non-commercial purposes, may be considered to be excluded from the scope of the breeder's right, and farmers who conduct these kinds of activities freely benefit from the availability of protected new varieties.

- Acts done for experimental purposes. The breeder's right does not extend to the use of the protected variety for experimental purposes.
- "Breeder's exemption. The exception under Article 15(1)(iii) states that the breeder's right shall not extend to "acts done for the purpose of breeding other varieties, and, except where the provisions of Article 14(5) apply, acts referred to in Article 14(1) to (4) in respect of such other varieties.". This is a fundamental element of the UPOV system of plant variety protection known as the "breeder's exemption", whereby there are no restrictions on the use of protected varieties for the purpose of breeding new plant varieties. The wording also clarifies that, except for the varieties included in Article 14(5), i.e. essentially derived varieties; varieties which are not clearly distinguishable of the protected variety and varieties whose production requires the repeated use of the protected variety, the commercialization[1] of the new varieties obtained does not require the authorization of the title holder of the protected variety used to create those new varieties.



* Except for:
(i) varieties which are essentially derived from the protected variety, where the protected variety is not itself an essentially derived variety,
(ii) varieties which are not clearly distinguishable in accordance with Article 7 from the protected variety and
(iii) varieties whose production requires the repeated use of the protected variety.[d]

[1] In this document the term "commercialization" is used to cover the acts included in Article 14(1) to (4) of the 1991 Act of the UPOV Convention.

Farm-Saved Seed (Optional) Exception

The Convention explains that, "[n]otwithstanding Article 14[2], each Contracting Party may, within reasonable limits and subject to the safeguarding of the legitimate interests of the breeder, restrict the breeder's right in relation to any variety in order to permit farmers to use for propagating purposes, on their own holdings, the product of the harvest which they have obtained by planting, on their own holdings, the protected variety or a variety covered by Article 14(5)(a)(i) or (ii)".

The inclusion of the optional exception in the 1991 Act of the UPOV Convention recognizes that, for some crops, there has been a common practice of farmers saving the product of the harvest for propagating purposes, and this provision allows each member of the Union to take account of this practice and the issues involved on a crop-by-crop basis, when providing plant variety protection. The use of the words "within reasonable limits and subject to the safeguarding of the legitimate interests of the breeder" is consistent with an approach whereby, if the optional exception is implemented, it is done in a way which does not undermine the incentives provided by the UPOV Convention for breeders to develop new varieties.

Cooperation

It is estimated that, within UPOV members, protection has been sought for varieties of more than 2,500 genera or species. In 2007, more than 10,000 titles were granted to breeders by UPOV members. These figures indicate the scale of the UPOV system and demonstrate why cooperation between UPOV members is a key benefit of UPOV membership. In that respect, the guidance developed by UPOV for DUS testing promotes harmonization between members of the Union, thereby facilitating the exchange of information and reports of DUS testing. UPOV members have provided information on their practical experience in DUS testing for more than 2,000 genera and species on the basis that they are willing to share that experience with other UPOV members. Furthermore, there are agreements for cooperation in DUS testing between UPOV members in relation to more than 1,300 genera and species.

Conclusion

The role of plant variety protection in responding to the challenges of a changing world is to provide a legal framework and system of implementation that encourages plant breeding. Some of the key requirements have been set out in this paper. In order to respond effectively to the challenges of a changing world, there is an urgent need to provide an enabling framework that encourages creativity in all its forms, and plant breeding in particular. This requires an appropriate legal framework for an effective implementation of plant variety protection. The legal framework established by the UPOV Convention and the systems established by UPOV members for its implementation, including in particular the guidance and cooperation between members, have been shown to be successful in meeting the aims of plant variety protection (see paper on "Benefits of Plant Variety Protection").

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2 Article 14 "Scope of the Breeder's Right"

DISCUSSION

ADRIENNE LEGER (AGRICULTURE AND AGRI-FOOD, CANADA): You mentioned that, for the distinctness criterion, the variety needs to be clearly distinguishable. How is that done?

PETER BUTTON: Essentially, in most cases, distinctness is examined on the basis of a growing trial - a field growing trial - where the new variety is grown alongside other varieties, existing varieties of common knowledge, to ensure that it is different from those other varieties. This is a very simple summary, but the examination of distinctness is a very important part of the UPOV system and when you are dealing with applications for over 2,500 plant genera and species within UPOV, this is really quite a challenge and this is why international cooperation is really key in the UPOV system. Without that cooperation, UPOV members would have to find a way to develop experience and expertise in all those species - it would be an enormous undertaking. But we have a very efficient system. For example, UPOV members can exchange DUS reports, so that if they don't have experience in a particular species and another UPOV member has already granted protection for that variety, they can use the report from that other UPOV member, because distinctness is a global test. So, if a variety is distinct in one UPOV member, it means that it is distinct globally, not just for that UPOV member.

DOUG WATERHOUSE: And I guess, Peter, the other part is the high-level harmonization. It's not just the DUS cooperation, but the high-level harmonization between the laws, the thresholds and the testing procedures used in all countries.

AAD VAN ELSEN (PLANTUM NL, NETHERLANDS): You said in your talk that one of the purposes for EDV was to encourage cooperation, but I think that one of the main goals of the EDV concept was to avoid plagiarism and easy breeding. I think that was the main reason, I think you should not forget that it was meant to cover that.

PETER BUTTON: Clearly, the purpose of the EDV provision is to ensure that, for new varieties that are essentially derived from an initial, protected variety, there is a mechanism to ensure that the breeder of the initial variety has control of that variety and is adequately recompensed. That clearly was a major aim. Of course, the possibilities that existed with new techniques was one of the triggers for developing that mechanism, as a means of ensuring that it wasn't an easy way of developing a new, independent variety, with just a very minor change, a cosmetic change. And this was clearly the purpose behind the EDV concept.

FERDINAND SCHMITZ (BUNDESVERBAND DEUTSCHER PFLANZENZUECHTER, E.V, GERMANY): I am wondering whether you have a study about cost efficiency of the system in comparison to other systems. Because, of course, breeders can apply for protection and it is very important, especially for small species and small markets, to have a system that is affordable. And as we have to pay a lot of fees to the offices, we sometimes have doubts. If we compare it to other systems, it might not be too bad. Is there a study available for the benefits of the protection system and the costs which are related to obtaining a title?

DOUG WATERHOUSE: There aren't any current studies directly on that purpose; however, there have been studies in the past and I can answer on behalf of Australia. There was a study in the 1980s that looked at the bench-marking between patents and plant breeders' rights, under a study called "Australia's Plant-Breeding Needs". They did an economic survey and compared, not just the registration costs, but the full costs of preparing an application and they found that, generally, an application for plant breeders' rights was at least an order of magnitude cheaper that an application for patents. In Australia, that is still the case today, and I know that because I look after both the plant breeders' rights area and the plant patents area

EXPERIENCES IN KENYA

EVANS O SIKINYI*

Introduction

The Role of Agriculture in Kenya

Kenya has a total land area of 58.26 million hectares of which only 11.6 million hectares (20 per cent) receive adequate rainfall for rain-fed agriculture. The rest is arid or semi-arid. Out of these 11.6 million hectares only 7 million are used for agricultural production. In the early 1960s, Kenya had a population of about 20 million people and this is estimated to be 42 million in 2009. To be able to meet the challenges of the increasing population and demand for food, more land will have to be brought into agricultural production. The agricultural sector contributes 26 per cent of Gross Domestic Product (GDP) directly and 60 per cent of export earnings. Through links with manufacturing, distribution and service-related sectors, agriculture indirectly contributes a further 27 per cent to the country's GDP. About 80 per cent of Kenya's population live in rural areas and derive their livelihood largely from agriculture. However, increased agricultural productivity can only result from intensive utilization of high potential land; the sustainable use of arid and semi-arid areas (ASAL) and the adoption of appropriate technological packages including improved varieties and quality planting materials for all agro-ecological zones.

The challenges posed by global warming have resulted in unreliable rainfall and weather patterns, further complicating the rain-fed agriculture that Kenya has relied on in the past. This has resulted in moving into irrigated agriculture, efficient use of the available water and opening up of new lands for agriculture, which have required new varieties suitable for these new eco-systems and high-quality seeds for improved productivity. Opening up these regions has posed new problems with new pests and diseases, environmental issues such as salinity, all requiring new varieties that can withstand these new challenges. This has therefore called for breeding or availability of new varieties.

The diverse agro-climatic conditions that exist in Kenya have allowed the production of a wide range of crops, including agricultural and horticultural crops from tropical, sub-tropical and temperate plants. The horticultural sector, particularly floriculture, experienced the most growth during the 1990s in terms of production volume and acreage, varietal improvements, the number of growers and exporters. In tandem with this, the Government of Kenya implemented economic reform measures conducive to domestic and foreign investment, including liberalization of foreign exchange controls, establishment of retention accounts by exporters and duty waivers. This encouraged investment by both local and foreign investors, in particular in terms of infrastructure and introduction of foreign varieties. However, they had to be assured that their plant breeders' rights were protected before introduction of their elite new varieties.

The horticultural sector is the second highest earner of foreign exchange after tourism and tea in Kenya. Export volumes of fresh horticultural products grew from 57,363 tons, valued at 2.5 billion Kenya shillings in 1992, to 121,100 tons, valued at 26.7 billion Kenya shillings in 2002 (2009, 1 US$ = Ksh 75.0 Kenya shillings (approximate)). Floricultural products account for 55 per cent of all horticultural exports. This trend has continued particularly after introduction of the plant breeders' rights system that has encouraged breeding of new varieties, introduction of foreign varieties and improvement of various quality aspects in new varieties. The markets have dictated the type of varieties to be grown, particularly in the horticultural sector, i.e. the varieties of roses that fetch the highest prices, consumer preferences for the cabbages grown, the French bean or green beans resistant to rust, etc.

* Head, Seed Certification and Plant Variety Protection Kenya Plant Health Inspection Service (KEPHIS)

Seed Industry Development in Kenya

Development of the Kenyan seed industry started in the early 20th century and was supported by research on food, industrial and export crops, which supplied seeds and planting material.

The commercial seed sector started with the establishment of the Kenya Seed Company (KSC) in 1956 in Kitale to produce pasture seed for the colonial settlers. KSC continued to play a predominant role until the industry was partially liberalized in the mid-1980s. Full liberalization of the seed industry was effected in 1996. After this, several companies entered the seed business and by 2004, there were 46 (which had risen to 73 in mid-2009) registered seed companies largely dealing in cereals - maize, wheat, barley, oats, triticale and sorghum; oil crops - rapeseed, sunflower, pulses, vegetables, pasture seeds, other horticultural seeds and Irish potatoes. To support the sector the Government initiated research on coffee, pyrethrum, tea, sugar cane, major cereals (maize, wheat, sorghums and millets, rice) horticultural crops, cotton and tree crops. The annual increase in the number of registered seed companies is testimony to the value given to seed-quality matters and to the importance of improvement in agricultural production. Kenya certifies seeds under the OECD seed schemes and ISTA seed rules.

The seed companies (merchants) operate a chain of agents, sub-agents and seed stockists who distribute their seeds throughout Kenya. However, some planting materials and seeds are distributed through non-commercial channels. For example, farm-saved seed and farmer-to-farmer exchange may be used by small-scale farmers and "road-side" nurseries for forest and fruit trees, which may not have clearly documented sources. Various non-governmental organizations (NGOs) and community-based organizations (CBOs) play an important role in the distribution of non-commercial seed.

Institutions involved in Variety Development and the Seed Industry

The Ministry of Agriculture has the major responsibility for creating and promoting an enabling environment for the players in the seed industry through development of effective policies and strategies. It plays an important role in facilitating research, providing advisory and information services, undertaking review of policies and regulatory framework, and ensuring sanitary and phytosanitary measures.

In the past, plant variety development in Kenya was done mainly by the Kenya Agricultural Research Institute (KARI) for food crops, horticultural crops, industrial crops, pasture and fodder crops; the Kenya Forestry Research Institute (KEFRI) for tree-seed development; the Coffee Research Foundation (CRF); the Pyrethrum Board of Kenya (PBK); the Kenya Sugar Research Foundation (KESREF); the Tea Research Foundation of Kenya (TRFK); universities; seed companies and the International Agricultural Research Centers (IARCs). Rose breeders have organized themselves into the Kenya Breeders Group, which represents about 13 international breeders, for development and propagation of roses.

The Kenya Plant Health Inspectorate Service (KEPHIS) was established in 1996 to provide effective service delivery to the seed industry. Its mandate includes, plant variety evaluation, release and registration; plant variety protection; seed certification; plant protection and development and implementation of seed standards, as well as implementation of the national policy on introduction and use of genetically modified plant species in Kenya.

Under the Seeds and Plant Varieties Act, crops listed under Schedule II must undergo compulsory certification to be eligible for marketing as seed. Such crop varieties must be tested under the National Performance Trials for their Value for Cultivation and Use before they are released for commercialization. During the test the varieties must prove that they perform better than the existing varieties on the market. In other words, they are new and improved varieties. Upon release, these varieties are entered onto the National Crop Variety List, which includes all officially released varieties to be in commerce. It does not however list all vegetable crops and ornamental crops. Efforts are underway to create catalogues for the other crops not included.

Plant Variety Protection (PVP) in Kenya - Key Provisions

- Provisions for the protection of new plant varieties are contained in the Seeds and Plant Varieties Act of 1972, which became operational in 1975. The Act was revised in 1991, official regulations to guide the implementation of PVP service put in place in 1994 and the plant variety protection schemes published in 1997. Kenya acceded to the 1978 Act of the UPOV Convention on May 13, 1999. A revised draft of the legislation, which recognizes emerging national and global developments in the seed industry, has been done
- Kenya grants plant breeders' rights (PBRs) for all plant genera and species, other than algae and bacteria.
- Principle of national treatment, which allows nationals of other State members of UPOV to be treated in the same way as Kenyan nationals, as far as plant variety protection is concerned.
- Provision of interim protection allows an applicant to request a protective direction (interim protection) when applying for plant variety protection. An applicant with a protective direction in force enjoys similar rights as if the right had been granted. The protective direction ceases when a decision on whether the application for the grant of plant breeders' rights is accepted or refused is made, or at such earlier time as is provided under the law.
- DUS examination for plant variety protection uses central testing, where KEPHIS carries out variety testing, cooperation in DUS testing with UPOV members and testing on breeder premises for special cases.
- Plant breeders' rights enforcement. The enforcement of rights is the responsibility of the owner of the rights. However, the law provides for the plant breeder whose rights are infringed to seek redress in the courts of law by means of damages, injunction, account or otherwise. The Act also provides for a Plant and Seed Tribunal to determine any disputes arising from plant variety protection. Additionally, KEPHIS, being the designated Authority for phyto-sanitary, seed certification and PVP matters, has the added advantage of helping the enforcement of PBR through the licensing and certification process.

Experiences in Plant Variety Protection

Since the implementation of the PVP system in 1997, a total of 980 applications for PVP have been received. There was a slow rate of application in the initial stages. However, in 2001, there was a sudden surge in PVP applications from domestic breeders, reflecting an increased awareness among breeders in public institutions of the need to protect their varieties and the utilization of the notion of varieties of recent creation provided for under the UPOV Convention. Domestic (Kenyan) breeders have submitted 376 (38.37 per cent) of the total PVP applications, while 604 (61.63 per cent) have been from foreign applicants.

Table 1 Applications Received from 1997 to 2008

	Number of Applications		
Year	Domestic	Foreign.	Total
1997	11	128	139
1998	42	33	75
1999	16	45	61
2000	24	45	69
2001	164	33	197
2002	11	27	38
2003	7	25	32
2004	16	44	60
2005	53	44	97
2006	0	54	54
2007	28	64	92
2008	4	62	66
Total	376	604	980

Domestic Breeders

Domestic applications have been from public institutions (339) and private institutions (37)

Table 2 Public and Private Applications

Type of Institution	*Number of applications (1997-2008)*
Domestic Public Research Institutes	338
Domestic Public Educational Institutes	1
Domestic Private Companies	36
Domestic Individual Breeders	1
Foreign Entities	604
Total	980

Crops most frequently featured in Applications for Protection in Kenya.

The following Table shows the crop species for which large numbers of applications for protection were filed between 1997 and 2008.

Table 3 Crop Varieties most frequently featured in Applications

Plant Species		*Number of Applications (1997-2008)*
1	Rose	460
2	Maize	132
3	Tea	39
4	Wheat	32
5	Alstroemeria	31
6	Limonium	24
7	Pyrethrum	23
8	French bean	20
9	Chrysanthemum	19
10	Calla lilies	15

(Source: KEPHIS)

Agriculture Sector

Three hundred and forty-four applications have been filed for agricultural crops, making up 35.1 per cent of the total PBR applications received. Domestic breeders submitted 338 (98.3 per cent) of the applications in the agriculture sector while 6 (1.7 per cent) were foreign in origin.

The PBR applications in the agriculture sector are distributed in categories shown in the Table below:

Table 4 Distribution of PBR Applications for Agricultural Crops as of 2008

Crop	*Category*	*Source of Application*			*Total*
		Non-residents	*Residents*		
			Public	*Private*	
Oats	Cereal	-	1	-	1
Finger millet	Cereal	-	2	-	2
Barley	Cereal	-	-	8	8
Proso millet	Cereal	-	1	-	1
Pearl millet	Cereal	-	3	-	3
Sorghum	Cereal	-	7	-	7
Wheat	Cereal	-	32		32
Maize	Cereal	6	125	1	132
Tea	Industrial	-	14	25	39
Pyrethrum	Industrial	-	23	-	23
Eucalyptus	Industrial		8		8
Coffee	Industrial	-	4	-	4
Cotton	Industrial	-	2		2
Macadamia nut	Industrial	-	4	7	11
Sugarcane	Industrial	-	6	-	6
Safflower	Oil	-	1	-	1
Sunflower	Oil	-	10		10
Castor oil	Oil	-	2	-	2
Soybean	Oil	-	7	1	8
Brachiaria	Pasture	-	1	-	1
Rhodes grass	Pasture	-	5	-	5
Guinea grass	Pasture	-	1	-	1
Setaria	Pasture	-	2	-	2
Clover	Pasture	-	-	1	1
Pigeon pea	Pulse	-	4	-	4
Dolichos bean	Pulse	-	2	-	2
Runner bean	Pulse	-	-	1	1
Dry beans	Pulse	-	13		13
Peas	Pulse	7	-	-	7
Cow pea	Pulse	-	4		4
Mung bean	Pulse	-	3		3
Cassava	Root crop	-	2	-	2
Total					344

Horticulture Sector

The horticulture sector formed the bulk of PBR applications, with a total of 636 applications accounting for 64.9 per cent of the total PBR applications. Foreign breeders submitted 613 (98.4 per cent), while domestic breeders made 10 (1.6 per cent) of the applications in this sector. Applications were received for the following categories of horticultural crops (see Table below):

Table 5 Distribution of PBR Applications for Horticultural Crops as of 2008

Crop	*Category*	*Source of Application*				*Total*
		Non-resi-dents	*Residents*			
			Public	*Private*	*Joint public and private*	
Strawberry	Fruit	3	-	-	-	3
Passion fruit	Fruit	1	-	-	-	1
Raspberry	Fruit	1	-	-	-	1
Pineapple	Fruit	1				1
Avocado	Fruit	3				3
Alstroemeria	Ornamental	31	-	-	-	31
Aster	Ornamental	1	-	-	-	1
Carnation	Ornamental	4	-	-	-	4
Eryngium	Ornamental	1	-	-	-	1
Gypsophila	Ornamental	12	-	-	-	12
Bird of paradise	Ornamental	1				1
Hypericum	Ornamental	1				1
Limonium	Ornamental	18	-	6	-	24
Pelargornium	Ornamental	4	-	-	-	4
Phlox	Ornamental	4	-	-	-	4
Rose	Ornamental	460	-	-	-	460
Solidago	Ornamental	2	-	-	-	2
Tegetes	Ornamental	1	-	-	-	1
Calla Lilly	Ornamental	15	-	-	-	15
Chrysanthemum	Ornamental	19				19

Amaranthus	Vegetable	-	-	4	-	4
Rape seed	Vegetable	14	-	-	-	14
Pepper	Vegetable	1	-	-	-	1
Sweet potato	Vegetable	1	-	-	-	1
Tomato	Vegetable	-	-	1	-	1
Irish potato	Vegetable	-	4	-	-	4
French bean	Vegetable	20	-	-	-	20
Pea	Vegetable	1				1
Soybean	Vegetable	1				1
Total						636

Cash crops (non-food crops which may include agricultural and industrial crops specifically grown for sale and not food security) dominate PVP applications with 774 applications, comprising 78.98 per cent of the total applications in Kenya. The agricultural crop category accounted for 344 applications, making up 35 per cent of the total PVP applications in Kenya. Domestic breeders dominate the agricultural sector with 331 (96 per cent) applications out of the 344. The majority of the applications in the agricultural category are for cereals (oats, maize, barley, finger millet, proso millet, sorghum, wheat and pearl millet). This is followed by industrial crops (pyrethrum, tea, coffee, cotton, macadamia and sugar cane) and pulses (pigeon peas, Dolichos beans, runner beans, dry beans, peas and mung beans).

Horticultural crops account for 636 (64.90 per cent) of the total PVP applications. In contrast to agricultural crops, PVP applications in the horticultural category are dominated by foreign breeders with 610 (97 per cent). Ornamental crops constitute 570 applications, accounting for 90 per cent of the applications for the horticulture sector, 58 per cent of the total PVP applications in Kenya. Foreign applications for ornamental varieties stand at 557 (98 per cent). Roses dominate among the ornamentals with 460 (80.7 per cent) applications, followed by Alstroemeria with 31 (5.4 per cent).

Impact of Plant Variety Protection

The UPOV Report on the Impact of Plant Variety Protection (“Impact Study”) (*http://www.upov.int/export/sites/upov/en/publications/pdf/353_upov_report.pdf*) evaluated the impact of plant variety protection and membership of UPOV in Kenya, Argentina, China, Poland and the Republic of Korea. A number of parameters were used in the evaluation including the number of breeding entities, changes to investment in breeding, number of released varieties and the improvement of varieties. A summary of the study findings in Kenya is provided below as well as additional observations that were made.

Number of Breeding Entities

It has been observed that university scientists, who previously conducted academic research, became more interested in breeding commercial varieties, increasing the number of commercial breeders. Lines that had been developed for academic purposes were developed into improved varieties for protection and commercialization. Over the years the number of breeding entities has doubled, as shown in the Table below. It is important to note that there are entities that are involved in breeding several crops or commodities. Similarly, research Institutes such as KARI may have several research stations or centers developing different varieties of the same crop, e.g. maize for the dry zones will be handled by one station in that region, while high-altitude maize varieties will be developed by a different station in the appropriate region. New entrants, such as foreign seed companies, that breed outside Kenya but submit their varieties to the national testing and release system, were seen. Similarly, new domestic companies have access to new varieties developed by international research institutes that that are not permitted to officially release them. It should be noted that breeding entities in the floriculture industries have traditionally carried out most of the breeding work outside Kenya. However, there has been a substantial increase in the level of domestic breeding and the type of crops bred in Kenya in the recent past.

Table 6 Number of Breeding Entities per Crop for the Period 1990-1996 and 1997-2003

Crop	*1990-96*	*1997-2003*
Maize	9	16
Dry beans	5	9
French beans	1	4
Macadamia	1	2
Tea	2	5
Sweet potato	3	4
Sugar cane	1	1
Cassava	3	4
Irish potato	1	1
Pyrethrum	1	2
Sunflower	2	5
Cotton	1	2
Millet	2	4
Sorghum	3	8
Barley	1	2
Rice	1	3
Wheat	2	5
Cow Peas	2	4
Total	41	81

Investment in Plant Breeding

The level of investment has increased in the breeding and commercialization of new varieties. This has concentrated on the establishment of physical facilities and technology. The level of investment has, however, decreased in public institutions especially in land acreage and financial allocations for plant breeding. This is in contrast to private breeding institutions where financial investment has gone up and fields extended for research and seed multiplication purposes. As stated above, there are new entities which have set up breeding activities, involving land acquisition for research and seed production, seed processing etc. There are also other smaller entities that rent out equipment from existing entities. There has also been collaboration between domestic breeders and the International Institutes where either finished or near-finished products have been acquired for further testing and multiplication.

In general, it is difficult to get details from the breeders on the level of their investment, although it is evident that substantial investment has been made. At the same time, government funding for research has been reduced substantially and some breeding programs have been discontinued. There is a general feeling or policy that public institutions should be able to commercialize their innovations to fund their activities. Contract breeding with the private sector is also being encouraged. Presently, research mainly funded by donor agencies in collaboration with the Kenya Government. KARI for instance has invested in a modern biotechnology laboratory and greenhouses for breeding work at a number of their stations through donor funding. Several universities have similar facilities in place or are in the process of installing them.

As can be seen in Tables 4 and 5, public and private breeders have started to jointly develop new varieties for some crops, such as wheat and maize. PVP plays an important role in promoting this kind of public-private cooperation. It has been observed that some university scientists, previously conducting academic work, have started to breed commercial varieties, thereby increasing the number of commercial breeders (see Boxes 1 and 2). Another type of cooperation is developing between international research institutes under the Consultative Group on International Agriculture Research (CGIAR) and local seed companies, whereby the latter would undertake the commercialization of varieties bred by the former. PVP is expected to play an important role and its modalities are now under discussion The PVP system also encourages local breeders, including private farmer-breeders, to establish and commercialize new varieties (see Box 3). A private farmer selected her two varieties of strelitzia, of which one, “Betsy” has interim protection and is due for grant of breeder’s rights after completion of DUS testing.

Box 1

Climbing beans are new types of beans that are suitable for small-holder farmers. These are being bred under institutional and regional collaboration projects involving both university breeders and KARI breeders.

Varieties are being evaluated here for suitability for release and protection.

Box 2

Three varieties of "Quality Protein Maize" have now been released in Kenya through collaborative work between local seed companies, research institutes and the International Maize and Wheat Improvement Center (CIMMYT). These varieties have higher levels of tryptophane and lysine compared to normal maize varieties, thus providing high quality protein for human consumption and for animal feed. PVP facilitates this kind of cooperation by allowing the varieties to be commercialized in a way which ensures that all partners are rewarded for their work.

Box 3

Betsy: a Strelitzia variety (right) selected by Mrs. Muriithi (left). Mrs. Muriithi's application for PVP is under examination.

Number of Released Varieties

An increased number and range of improved varieties have become available to farmers. The number of varieties introduced by breeders within the period subsequent to the establishment of PVP is significantly higher than in the preceding period, especially for maize. Between 1990 and 1996, only 39 new varieties were released, as compared to 126 between 1997 and 2003 and the introduction of variety protection. Maize constituted about 50 per cent of these varieties. Most of the new varieties are superior to the existing ones, particularly in yield, pest and disease tolerance, nutritional qualities, tolerance to abiotic stress and earliness in maturity. All these varieties must pass through the National Performance Trials to verify the superior characteristics by KEPHIS before they enter commercialization. Since maize is a staple food for 80 per cent of Kenyans, this implies a positive contribution to food security concerns in the country. Three varieties of quality protein maize have now been released in Kenya through collaborative work between domestic seed companies, research institutes and the International Maize and Wheat Improvement Center (CIMMYT). More of these varieties suited for various agro-ecological zones are under test and will be released in the near future. These new varieties are licensed to private companies for effective distribution and wider adoption.

Table 7 Number of Officially-Released Varieties for Crops under the NPT (VCU) Tests per Crop from 1998 to 2008.

Year	Maize	Bush bean	Climbing bean	Sweet potato	Cassava	Pearl millet	Sorghum	Wheat	Potato
1998		1		3	3		3	3	2
1999	2			1				3	
2000	8					2	3		
2001	13			4		1		3	
2002	10								
2003	21								
2004	22								
2005	4								
2006	11								
2007	7							2	
2008	42	11	3		6		4	2	
Total	140	12	3	8	9	3	10	13	2

Improvement of Released Varieties

Previously, varieties were assessed for release on the basis of their yield performance. However, in the recent past varieties have been released on attributes other than yield. For instance, it is a requirement that for any new maize varieties to be released they must have a specified level of tolerance/resistance to turcicum blight and grey leaf spot, as a minimum, in addition to other characteristics. Other aspects that have been used include quality, such as quality protein in maize, baking quality in wheat, disease and pest resistance, brewing quality in barley, etc. These requirements have demanded improvement on the already released varieties. For example, a number of maize varieties are being converted to quality protein maize with resistance to abiotic and biotic stresses.

The provision of the breeder's exemption has allowed Kenyan breeders to develop new varieties of French beans resistant to rust using the released or protected varieties as sources of variation. These varieties are in the final stages of release.

With regard to plants that are not covered by the variety release requirements, such as ornamental crops, the availability of globally important varieties, as a result of offering protection to breeders of those varieties, has resulted in increased opportunities for the flower industry, as explained below.

Additional Observation and Findings

Increased Breeding Activities, Commercialization and Collaboration

An increased level of activity has been observed in the seed market among domestic and foreign breeders. At the same time, increased collaboration of domestic breeders with foreign breeders and international institutions has been reported. This involves capacity-building, funding, germplasm exchange and commercialization of foreign varieties in Kenya. Domestic breeders have also extended partnerships with farmers for on-farm testing of newly bred varieties. Domestic entities receive and market new materials from foreign breeders on their behalf or under license. Alternatively, these breeders have incorporated their companies domestically to market their new varieties.

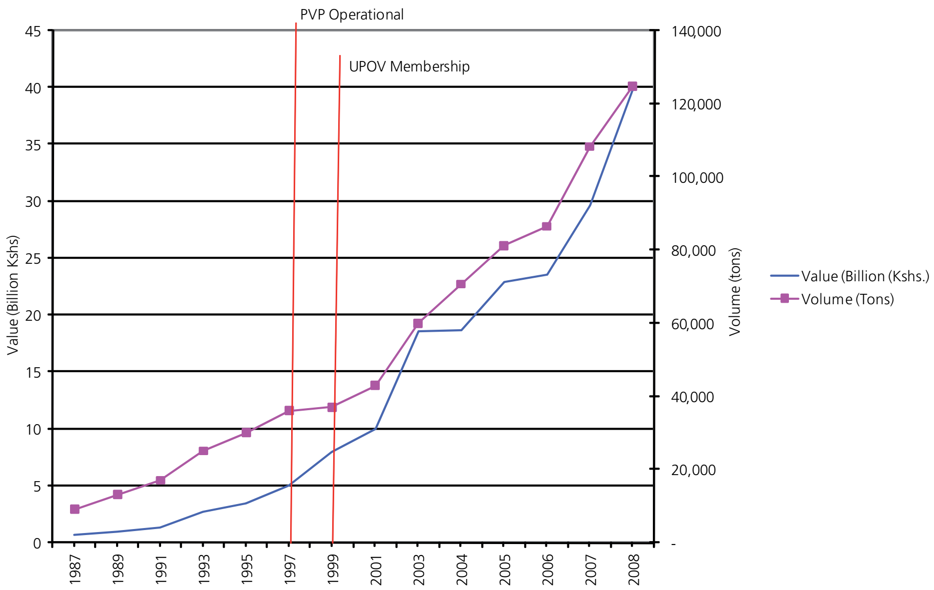
Enhanced Access to Foreign-Bred Materials

Most of the applications for PVP in Kenya are from foreign breeders (55 per cent). This demonstrates increased availability of foreign germplasm, which can be used further in developing improved varieties in accordance with the breeder's exemption in the UPOV Convention. For example, a breeder at Moi University has developed a number of lines from an introduced foreign-protected variety crossed with a local bean variety that has rust resistance. One of the developed lines is under trial for protection and commercialization (see Box below).

Generation of Foreign Exchange and Employment

More than half (52 per cent) of the varieties for which PVP has been applied in Kenya are ornamentals. Given the conducive weather conditions for flower and ornamental plant production, Kenya has continued to attract a number of breeders to grow their new varieties for the European market. Kenya remains the largest single source of floriculture imports into the European Union. To sustain production, the floriculture industry employs a large labor force, which is an important source of income for the small-scale farmers located in the rural areas. It is estimated that the horticultural industry employs 2 million people directly in breeding, production, packaging and transport. Another 3.5 million people are supported indirectly by the industry, for instance in marketing, the hospitality industry, manufacturing of containers, etc. There are over 160 professional-size growers, who include small-scale (under 4 hectares), medium-scale (10 to 50 hectares) and large-scale growers (over 50 hectares). In the early stages of development, there were a few large-scale growers dominating the industry. However there are now more than 100 medium- to large-scale growers. In 2003, Kenya exported over 61,000 metric tonnes of cut flowers to Europe, up from 52,000 metric tonnes in 2002. The value of that export was 216 million US dollars. On overall horticultural production in 2008, 7 million tons were produced and used domestically, while 403,000 tons were exported, accounting for about 4 per cent of total production. These were worth 1.8 US dollars billion for the domestic market and 1.0 billion US dollars in export markets.

Fig. 1 Export of Kenyan Cut Flowers



Summary and Observations

During the 10 years (1997 to 2008) that the PVP system has been operating in Kenya, the following observations have been made on the impact of the introduction of the PVP system and the accession to the UPOV Convention:

The establishment of the PVP system in Kenya has stimulated interest in commercial breeding which has spread all over the country, but in particular in the private sector and in the horticultural sector which is now found in newly opened areas and regions.

- Increased investment in plant breeding, particularly by the private sector.
- Increased competition and collaboration in the seed industry in terms of variety development and marketing of new varieties.
- Increased awareness of the benefits of plant-variety protection by breeders and employers.
- Most research institutions and breeding entities now have institutional Intellectual Property policies and Intellectual Property offices in place to guide technology development and transfer.
- Increase in the number and range of foreign varieties which are used for agricultural production and source of variation for further domestic breeding of new varieties.
- Creation of employment and foreign exchange earnings from the increased production in the horticultural sector, particularly for export.
- More domestic varieties are tested for release and commercialization by the domestic breeders for the domestic market.

Conclusions

Kenya has been faced with a wide range of challenges due to a changing world. These changes have included global warming which has affected the weather patterns and traditional agricultural practices which have required new technologies. The population increase demands increased food production, which requires increased productivity and expansion of production areas. This was previously limited by the available arable land, but it may be solved by new technologies for farming in the more arid land that is available. Similarly, farmers have had to move from subsistence farming to more commercial or business farming. In all this, new plant varieties and quality seeds have had to play a major role in meeting the challenges. New plant varieties and crops have been used to produce crops and food in areas not traditionally used for production. The floriculture industry in Kenya has flourished and is a major income earner and employer and supports millions of Kenyans. This has been driven by changing demands in consumer preferences and availability or ability to provide new varieties to meet the demand. Breeding new varieties and particularly the introduction of new foreign varieties has been crucial in cases where domestic breeding faced challenges in developing appropriate varieties.

Plant variety protection has played a greater role in meeting these challenges since it encourages innovation and investment in breeding, introduction of new varieties and commercialization of agricultural production. High quality seeds of the new varieties have been shown to be a sure way to meet the challenges of the changing world.

Discussion

FRANÇOIS BURGAUD (GNIS, FRANCE): Dr. Sikinyi showed a map of Africa and the situation of breeders' rights in Africa and the map is linked to the membership of UPOV, but it doesn't reflect the situation on legislation. So I would like just to add that 16 countries are members of the African Intellectual Property Organization (OAPI), which already has legislation on plant breeders' rights that is implemented and there are some protected varieties. There are also some countries in North Africa with legislation, so the situation is not as bad as it looks on Dr. Sikinyi's map.

DOUG WATERHOUSE: I also saw that Dr. Jördens had a map which demonstrated the point that you have made.

ROBERT GUEI (FAO): Firstly, can you actually tell us about the experience of your country in terms of law enforcement, because law enforcement is very important? How do you do that in Kenya? Secondly, when you talk about foreign germplasm or varieties coming in, are you talking only about the private sector, or are you talking also about Consultative Group on International Agricultural Research (CGIAR) centers? It is not clear to me what role the CGIAR centers based in Kenya play.

EVANS SIKINYI: Maybe one of the issues when we implemented plant breeders' rights was the question of enforcement. KEPHIS, as an organization, is in a better position because apart from issuing plant breeders' rights, it is also responsible for the inspection of material that is exported. We have records of all seed certification exported material, so we are in a position to assist in enforcement. In terms of foreign varieties, these were from the private sector. However, there is a lot of collaboration between local breeders and the international research centers which we have in Kenya. They have assisted in the development of releasing varieties, although materials from international research centers have not been entered for protection, but are available for commercialization. However, if breeders further develop the material from international research centers, they are free to protect it – as long as it has been further developed into a new variety.

JEAN-LOUIS DUVAL (JLDUVAL CONSULTING SARL, FRANCE): Was the public sector in Kenya reluctant to become involved in enforcement?

EVANS SIKINYI: The plant breeder's right is a private property right and enforcement is for the owner of the variety, the one with the grant. However, as an office, we will assist in cases of infringement where we can provide evidence. However, as I said, KEPHIS has gone out of its way to try and assist in keeping records. Most of the applications from local breeders are from public institutions. One of the reasons why public institutions were a little bit slow to apply for protection was a lack of awareness and also a lack of IP policy, because the breeders didn't see what was in it for them. The institutions did not initially understand why they should put in money to protect varieties. So with awareness, awareness-creation, and now also putting IP policies in place where institutions are spelling out what would be the benefit to the breeder or the benefit to the institution, there's more interest in protecting new varieties.

EXPERIENCES IN THE REPUBLIC OF KOREA

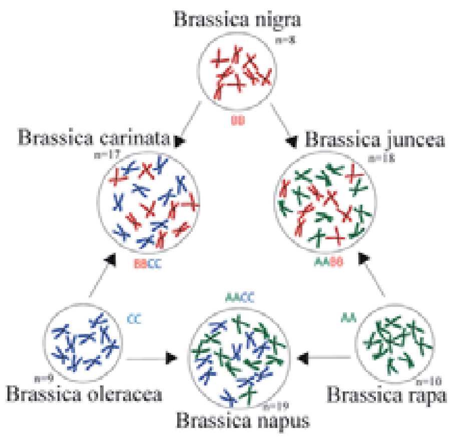
Mr. CHANG HYUN KIM*

Introduction

The Republic of Korea introduced its Plant Variety Protection (PVP) system in 1997. There were several reasons for its introduction at that time.

First, there was a strong demand to develop the breeding industry. Korean modern breeding started in the 1950s, when Dr.Woo Jang-Choon, who demonstrated the genetic relationship between six species of the genus Brassica, (the "Triangle of U"), led the Central Agricultural Technology Research Institute (CATRI). Dr.Woo and his staff bred many varieties, mainly vegetables, and distributed those basic varieties to private seed companies. Later, many employees of CATRI became private breeders with various seed companies who bred important vegetable varieties such as the hybrid variety of red hot pepper named "Bulam House Put" using a Genic Male Sterility (GMS) line, the first in the world, in 1969. However, breeders could not protect their varieties effectively without a PVP system, although they mainly focused on breeding hybrid varieties. Therefore, they demanded an effective system.

<Triangle of U>



< Dr.Woo Jang-Choon >

Second, there was a need for a legal framework to support the export of agricultural and horticultural products, especially cut flowers and ornamental crops, which have been exported since the mid-1990s. In order to support and facilitate export, new varieties that were adapted for foreign markets were needed by farmers.

However, there has been another consistent challenge, which is that farmers and consumers always want improved varieties which offer better quality and higher yield. To meet this challenge, breeders need an effective incentive to breed new varieties.

This report explains the experiences in the Republic of Korea in meeting those challenges by the introduction of a PVP system and accession to the UPOV Convention.

* Director General, Korea Seed & Variety Service (KSVS)

General View of Agriculture in the Country

Approximately 70 per cent of the Republic of Korea is covered by mountains. Only 15 per cent of the land area is flat, and mostly located along the coast. 17.9 per cent of the land is used for agriculture, while 64 per cent is used for forestry (2007). The Republic of Korea has a temperate climate with four distinct seasons and, in addition, traits of an oceanic climate. Average annual precipitation varies from 1,016 mm to 1,524 mm.

As a result of the rapid economic development of the country, the workforce active in the agricultural sector fell from 49 per cent in the 1940-50s to 6.8 per cent in 2007. The average farm size is now around 1.45 hectares.

The Republic of Korea is a net importer of staple crops. Rice, the most important pf these, is the only exception, where domestic consumption can be covered by the national production. The level of domestic self-sufficiency for grain crops is 25.3 per cent. Most other grain crops, such as corn and wheat, have a self-sufficiency level of less than 5 per cent and these crops rely on imports.

Table 1 Cultivated Area by Crop (2007, unit: 1,000 ha.)

Rice	*Other Food Crops*	*Specialty Crops (Industrial, Medicinal)*	*Vegetables*	*Fruits*	*Others*
950	211	80	222	148	244

Vegetable production is a very important sector in Korean agriculture, with an annual production value of 7,483 billion won, in comparison with fruit (2,822.3 billion won in 2007). Vegetable production meets the national demand, and some competitive crops, such as sweet pepper and tomato, are also exported. The most important vegetables include hot pepper, Chinese cabbage, radish, cucumber, garlic, water melon and onion. Traditional vegetables, such as perilla, oriental melon and sesame, are also important.

Table 2 Agricultural Production by Crop (2007, Unit: million US$, 1 US$ = 929.20 KRW, 2007 Average Exchange Currency)

Rice	*Other Food*	*Vegetables*	*Fruits*	*Flowers*	*Mushrooms*	*Specialty Crops*	*Others*
8,456.2	1,127.9	8,053.2	3,037.3	994.1	485.5	1,247.1	1,904.2

Among fruit crops, deciduous fruits such as apple, grape, pear and persimmon are important. Flower production has recently increased to respond to the increased demand for ornamental plants by domestic consumers. The Korean export flower business is expanding rapidly.

Short Description of the Seed Industry

The value of the seed market in the Republic of Korea is estimated at 581 million US dollars and, on the basis of a worldwide seed market value of 36.5 US billion dollars , it accounts for 1.5 per cent.

Table 3 The Size of the Seed Market in Korea (Unit: million US$)

Total	*Food./Grain*	*Horticulture*			*Forage*	*Seedling*	*Others*		
		Vegetable	*Ornamentals*	*Fruits*			*Industrial crops*	*Mushroom*	*Seaweed*
581	50	150	110	40	20	100	60	40	11

Year 2007, (Source: MIFAFF estimate)

The seed supply of traditional main crops, such as rice, barley, soybean and seed potato, has been mainly conducted by the public sector (KSVS: Korea Seed and Variety Service). Almost all the necessary seed required has been produced domestically. The participation of the private sector in the seed production of these crops is now beginning.

Conversely, private companies have been the main players in the supply of vegetable seed: red pepper, Chinese cabbage, radish, watermelon, oriental melon and onion are the most important seed-propagated vegetable species.

Since some multinational seed companies entered the Korean seed market in the late 1990s, there has been very strong competition between domestic and multinational companies.

It is also important to note that a considerable amount of seed for national vegetable production is produced abroad and shipped into the country, even though many varieties of vegetable crops are bred in Korea. That is due to the unfavorable conditions for vegetable seed production, including climate, high costs, etc. in the Republic of Korea.

Plant Variety Protection System

Law/Regulations

The Seed Industry Law of the Republic of Korea, based on the UPOV Convention, was promulgated on December 6, 1995. The Republic of Korea revised its Law in 1997 in accordance with the provisions of the 1991 Act of the UPOV Convention, and became a member of UPOV on January 7, 2002.

History of 'Seed Industry Law'
- 1995.12 Established
- 1997.12 Implemented on Dec. 31, 1997
- Revision of the Law in a few articles
  - in 1999, 2001: Conformity with the UPOV Convention such as the notion of breeder, variety, denomination, etc.
  - 2003 : Provisional protection revised
  - 2007 : Introduction of dispute settlement mechanism

History of PVP in Korea
- 1997.12 : Introduced the PVP Scheme
- 2002. 1 : Joined as the 50th UPOV member
- 2003. 12 : Strengthened provisional protectio-came into effect from 2005.3.
- 2009. 5 : All plant genera and species without six crops are entitled to PVP

* strawberry, raspberry, blueberry, mandarin cherry and seaweed

Authorities

Since 1998, the Korea Seed and Variety Service (KSVS) under the Ministry for Food, Agriculture, Forestry and Fisheries (MIFAFF) has been operating the PVP system in the Republic of Korea.

KSVS is the organization responsible for implementing several regulations (articles) under the law such as recruiting skilled personnel, securing testing fields, equipment and facilities. In addition, KSVS has studied the PVP operation (management) systems of foreign countries in order to develop and implement the PVP system in Korea.

In August 2008, the Korea Forest Seed and Variety Center was established for PVP in the field of forestry, within the Korea Forestry Service.

Genera and species eligible for protection

The number of plant genera and species covered by PVP has increased steadily since the introduction of PVP. As of May 1, 2009, all genera and species became eligible for PVP, except for strawberry, raspberry, blueberry, mandarin, cherry and seaweed.

Accordingly, many varieties from diverse genera and species are expected to be the subject of applications for PVP in future, and applications for foreign varieties are expected to increase. Table 4 shows the change in the number of species eligible for PVP by year. The PVP system in the Republic of Korea is required to cover all genera and species by 2012 at the latest.

Table 4 The Number of Genera and Species Eligible for Protection

Year	*1998*	*2000*	*2001*	*2002*	*2004*	*2006*	*2008*	*2009*	*2012.1*
Increased number	27	30	31	25	42	34	34	All except for six plants*	All plants
Accumulated number	27	57	88	113	155	189	223		

* Excluding certain genera and species of strawberry, raspberry, mandarin, blueberry, cherry, seaweed.

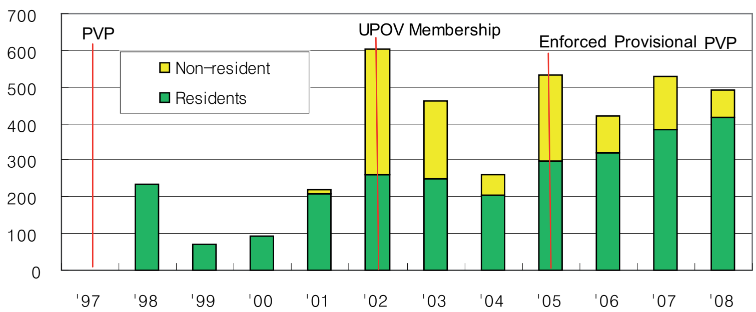
Impact of Plant Variety Protection

Overall Trends of Varieties Available in Korea

(i) Number of Varieties

As shown in Fig. 1, the Republic of Korea recorded a large number of PVP applications by domestic residents immediately after the introduction of PVP in 1997.

Fig. 1 Number of Applications (1998~2008)



Following accession to the UPOV Convention, there have been two noticeable peaks in the number of applications. The first peak was recorded in 2002, the year in which the Republic of Korea acceded to the Convention. The second peak was recorded in 2005 when the provisional protection amendments, introduced in 2003, came into force. Until February 2005, applicants were only provided with provisional protection after the completion of the DUS test. Since March 2005, applicants have the right of provisional protection from the date of publication of the application.

Fig. 2 Number of Applications by Categories of Crop

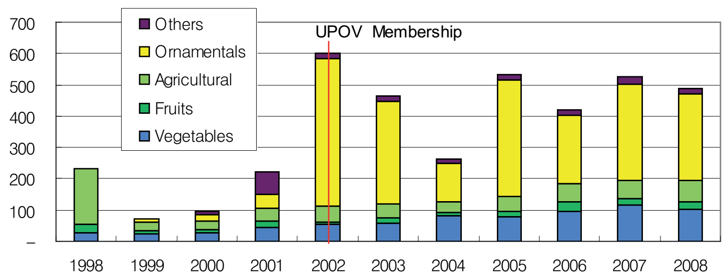


Fig. 2 demonstrates that the number of applications for PVP in vegetables has increased steadily since its introduction in 1997: the introduction of PVP stimulated domestic breeding very strongly in the vegetable sector. The number of applications for PVP in agricultural species reached a peak in 1998, which was accounted for by a large number of varieties that had recently been developed by government research stations. The PVP Law of the Republic of Korea, in conformity with Article 6(2) of the 1991 Act of the UPOV Convention (varieties of recent creation), enables such varieties to be protected.

In 2002, the year in which the Republic of Korea acceded to the UPOV Convention, there was a wide response in terms of PVP applications for varieties of ornamental species, mainly by foreign applicants. Important ornamental species such as chrysanthemum, lily and rose first became eligible for protection in July 2001.

As shown in Fig. 3, the first PVP title was granted in 2000. Since then the number of titles in force has been increasing continuously.

Fig. 3 Number of PVP Titles Granted and in Force

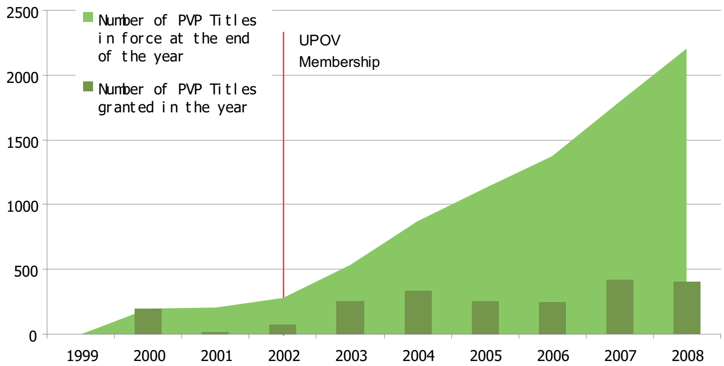


Table 5 shows that farmers in the Republic of Korea have seen the introduction of a number of new, protected varieties of important agricultural, vegetable and ornamental crops.

Table 5 Number of Titles granted from 2000 to 2008 by Crop Category (Top Five Crops)

Order	*Agricultural*		*Vegetables*		*Ornamental*	
	Crops	*No.*	*Crops*	*No.*	*Crops*	*No.*
1	Rice	202	Hot pepper	78	Rose	476
2	Soybean	101	Chinese cabbage	52	Chrysanthemum	262
3	Barley	71	Radish	49	Chin cactus	82
4	Maize	48	Water melon	39	Gerbera	81
5	Potato	35	Lettuce	31	Kalanchoe	79

ii) Improvement of Varieties

Since the introduction of PVP in Korea, many improved varieties have been seen in various agricultural and horticultural sectors, for example:

Rice
Recently, there have been changes in the breeding objectives for rice in the Republic of Korea: besides high productivity, new objectives, such as high quality for cooking and processing, reliability for cultivation (e.g. direct seeding, resistance to stress, etc.) and diversification of use (e.g. diet food, healthy food, feed, etc.) have been added.

Rice varieties with high-quality endosperm are demanded by consumers in the Republic of Korea. The endosperm of milled rice in recently developed rice varieties has been significantly improved (see Box 1).

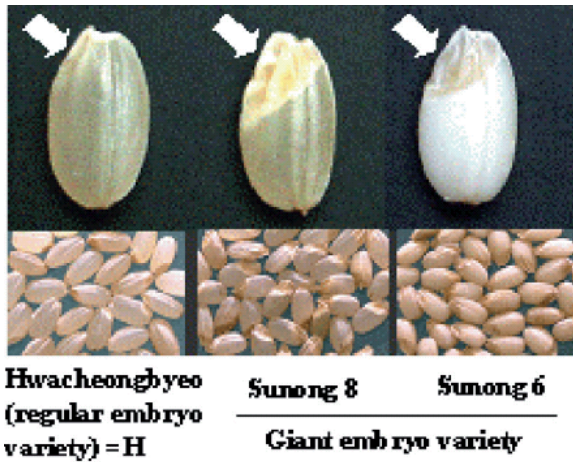
Seoul National University has developed a series of new types of rice varieties. For example, varieties with a giant embryo ("Sunong 6" and "Sunong 8") contain higher levels of various functional components such as oryzanol, phytosterol, tocopherol, and dietary fibers in comparison to varieties with a regular embryo (see Box 2).

Box 1

The premium quality milled rice variety "Ilpum", protected in 2004, with translucent endosperm (left) and the conventional milled rice "Yangjo", protected in 2000, with some white belly (right)

Box 2

Varieties with a giant embryo"Sunong 8" (centre), "Sunong 6" (right)



Hot Pepper

Varieties which grow well in high temperatures have been bred for cultivation in greenhouses, and varieties which are resistant to phytophtora blight have also been bred (see Box 3).

Box 3 Diversification of Red Hot Pepper Varieties

DokYaCheongCheong (Breeder : Lee YongJik, Ji Yeong-gwon, Syngenta,Korea)

1) Strong resistance to phytophthora blight
2) Easy growing because of virus resistance
3) Low-wilting symptom because of resistance to wet damage
4) High yield and good quality of dry fruits
5) Correct degree of spiciness
6) Easy harvesting

Super Manita (Breeder: Choi Soon Ho, Sim Dong Bo, Nongwoo Bio)

1) Variety bred for protected cultivation.
2) Large fruit with high pungency.
3) High yield by excellent fruit setting.
4) Resistant to CMV-fny
5) Good quality of dry fruits.

Rose
The diversification of varieties has been rapid in ornamental crops. Most varieties of rose that were introduced and marketed previously were standard types. However, spray and pot type varieties have recently been added to the standard varieties. The favored colors for rose flowers were red, white and pink, but they have been diversified to bi-colors, pastel (orange), green, etc. (see Box 4).

The increased availability of new rose germplasm, resulting from the introduction of foreign rose varieties, has strengthened the rose breeding sector in the Republic of Korea. Applications by domestic breeders have been increasing recently (see Box 13, breeder's exemption).

Box 4 Diversification of Rose Varieties (Spray Type/Pastel Color)


Standard Type (Bi-colors)


Spray Type


Pastel (Orange)


Green

Ginseng
Eight new ginseng varieties have been bred by private breeders at the Korean Tobacco & Ginseng Corporation (KT&G) and have received a breeder's right. Applications for the protection of two further varieties have been filed. In ginseng, the percentage of high quality ginseng roots, "red ginseng" is one of the most important commercial characteristics. The newly developed varieties show a high proportion of red ginseng (20 to 38 per cent), compared to 15 per cent for the average conventional ginseng varieties), as well as a higher root yield (see Box 5).

Box 5 High Quality Variety "Chunpoong"

Varieties	*Root yield (ton/ha)*	*Red ginseng percentage*
Chunpoong	6.39	38.00
Average of conventional varieties	5.46	15.00

Box 6 KSVS Korea Top Variety Award's

KSVS has made Korea Top Varieties awards since 2005. The following varieties were selected:


1st (2005)
Apple
"Hong-ro"


2nd (2006)
Rice
"Donggin 1ho'"


3rd (2007)
Water Melon
"C-zero"


4th (2008)
Lily
"Dusan"

The key features of those varieties are as follows

Apple
"Hong-ro"
(Breeders: Shin Yong-uk , Kim Whee-cheon, Kang, Sang Jo, Moon Jong-yeol, Kim Jung-ho, Rural Development Administration)

- Early maturing variety
- Large fruit, available before Korean Thanksgiving Day
- Superior skin color (bright red), high sugar content
- Low production cost due to high density planting and non-bagging
- Excellent marketability due to low fruit dropping before harvest and skin russeting

Rice
"Donggin 1ho'"
(Breeders: Kim Bo-kyeong, Shin Hyun-tak, Lee Jae-Kil, Ko Jae-kwon, Shin Mun-sik, Ko Jong-cheol, Choung Jin-Il, Ha Ki-yong, Kim Ki-young, Kim Young-doo, Nam Jeong-kwon, Kim Yeon-kyu, Kim Soon-chul, Rural Development Administration)

- Good plant type, medium-late maturing variety, good color of unhulled grain in ripening stage
- High level of resistance to lodging, abiotic stress, bacterial leaf blight
- High palatability and milling ratio
- Wide adaptability

Water Melon
"C-zero"
(Breeder: Lee Sang-jae, Syngenta, Korea)

- Seedless, triploid variety
- Easy cultivation due to strong plant vigor, resistance to abiotic stress
- Low consumption of chemicals due to high level of resistance to biotic stress
- Excellent marketability in terms of sweetness, flavor, flesh color

Lily
"Dusan"
(Breeder: An Jae Young, farmer-breeder)

- Variegated, glossy leaf, mild flavor, cut-flower purpose,
- Pure white colored flower, upward flowering
- Four to six flower setting, even in scale or small bulb planting superior marketability and suitability for export
- Strong plant, high level of resistance to biotic stress, easy cultivation management low production cost

(b) Domestic Breeding

(i) Number of Varieties

Table 6 shows the number of applications for PVP filed by residents (domestic breeders). It indicates that, for important agricultural and vegetable crops such as, rice, hot pepper, Chinese cabbage and radish, etc., domestic breeders play a major role. Rice is a main food crop and hot pepper, Chinese cabbage and radish are main ingredients for Kimchi (see Box 7), which is an important side dish in the Republic of Korea. Domestic breeders are also active in the breeding of traditional crops, such as ginseng (see Box 5) and perilla (see Box 8). Foreign breeders predominate in the breeding of ornamental crops (see Table 12). However, some applications for ornamental varieties, such as rose and chrysanthemum, originate both from domestic and foreign breeders. Breeding of Chin cactus varieties is also very active because the Republic of Korea is the largest worldwide exporter (2,522,735 US dollars in 2008) (see Box 9).

Table 6 Number of Applications by Residents by Crop (Top 10 Crops, 1998~2008)

	Crop	*No*
1	Rice	241
2	Rose	191
3	Chrysanthemum	173
4	Hot pepper	146
5	Soybean	114
6	Chin cactus	108
7	Chinese cabbage	103
8	Lily	91
9	Radish	90
10	Barley	84
Total		1,341
Total applications by residents		2,750

Table 6.1 Number of Applications by Residents by Crop (Top Five Crops, 1998~2008)

	Agricultural		*Vegetable*		*Ornamental*	
	Crops	*No.*	*Crops*	*No.*	*Crops*	*No.*
1	Rice	241	Hot pepper	146	Rose	191
2	Soybean	114	Chinese Cabbage	103	Chrysanthemum	173
3	Barley	84	Radish	90	Chin Cactus	108
4	Maize	79	Water melon	72	Lily	91
5	Potato	47	Lettuce	59	Phalaenopsis	66

Box 7 Kimchi

Box 8 Perilla
(bred by the Rural Development Administration)

Box 9 Chin Cactus varieties

Dahong Hwang-jo

(ii) Number of Breeders/Investment in Breeding

Number of Breeders

There have been some crops for which a notable change has been observed in the number of breeders.

As shown in Fig. 4, a sharp increase in the number of rose breeders was observed in 1996. In that year, the number of companies increased from one to 13 and four "new" individual breeders also appeared.

Fig. 5 shows a similar development in the rice-breeding sector where the number of breeders has increased in various institutions such as private companies, universities and government research stations.

Fig. 4 Number of Rose Breeders

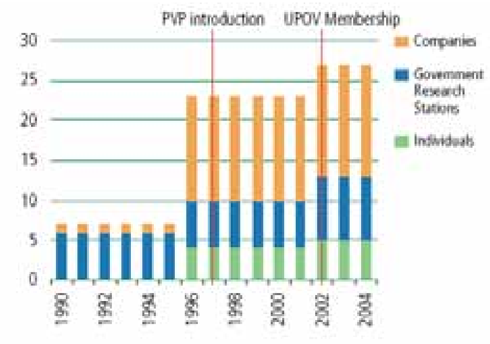
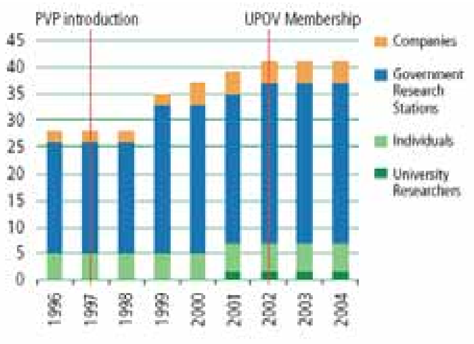


Fig. 5 Number of Rice Breeders



Since the introduction of the PVP system in the Republic of Korea, the number of applications from the private sector has increased continuously (see Figs 6 and 7). In the public sector, the number of applications by central government has been relatively stable, but the number of those by local governments is increasing (see Figs 8 and 9). The increase in the number of applications by local governments is related to investment for the breeders of new varieties, developed for their local farmers.

Fig. 6 Number of Applications by Domestic Individual Breeders

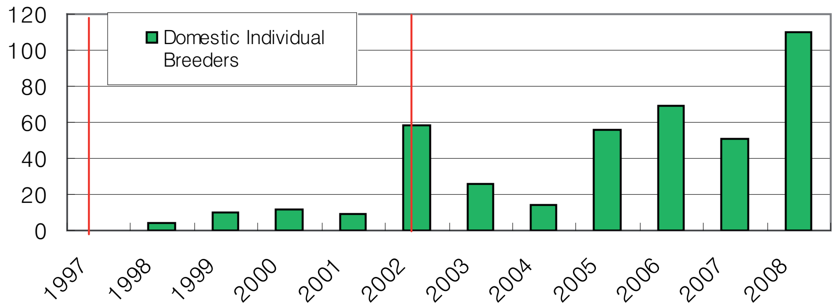


Fig. 7 Number of Applications by Domestic Seed Companies

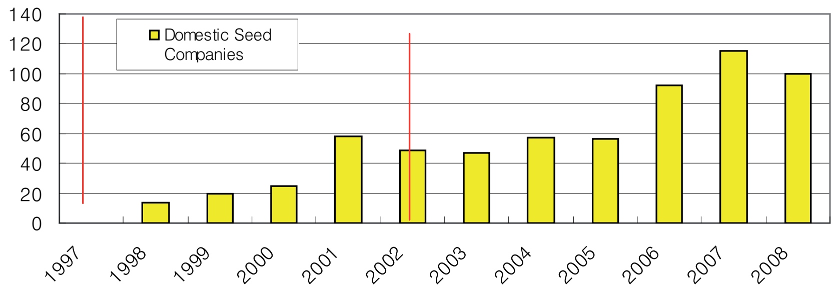


Fig. 8 Number of Applications by Domestic Local Governments

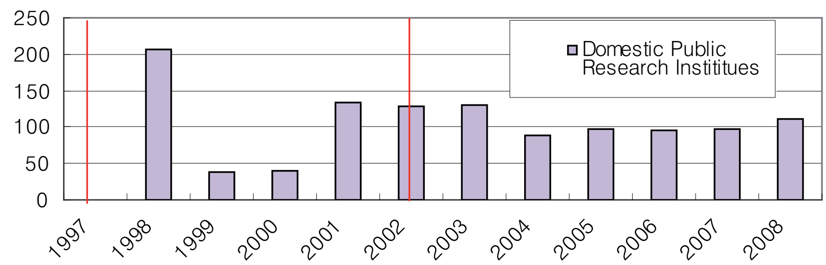


Fig. 9 Number of Applications by Domestic Central Government

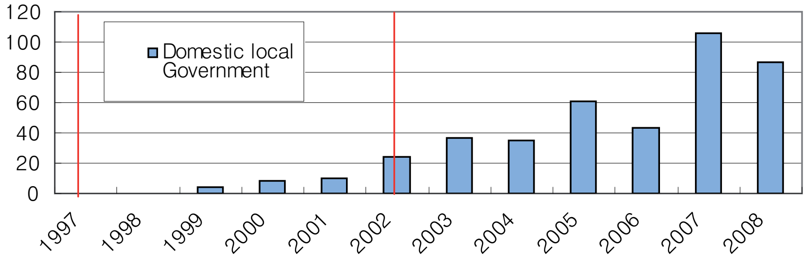


Table 11 Number of Individual Breeders by Crop (May 2009)

Total	*Agricultural crops*	*Fruit*	*Flowers*	*Vegetables*	*Mushrooms*	*Industrial crops*
445	24	64	188	85	66	17

Table 11 shows the number of individual breeders by crop. The introduction of PVP and other government incentives for breeders was associated with an increase in the number of individual breeders. This policy encouraged many potential breeders and growers, who were not previously actively involved in breeding, to take an interest in active breeding work.

Investment in Breeding

Fig. 10 demonstrates that investment by companies breeding Chinese cabbage increased considerably in 1999 and 2000, after the introduction of PVP. The much lower level of investment by the government research stations has remained relatively stable.

The domestic breeding of roses was first started in government research stations in 1991 and was later followed by private companies. As shown in Fig. 11, investment by rose-breeding companies has increased steadily since the introduction of PVP. Government research stations have also increased their investment, with a significant peak in 2000, reflecting substantial investment in infrastructure for rose breeding, such as new greenhouses and breeding fields.

Fig. 10 Breeding Investment-Chinese Cabbage

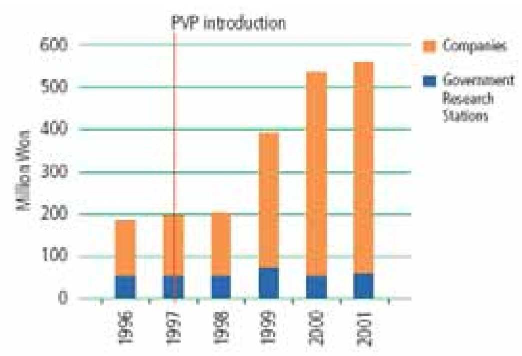
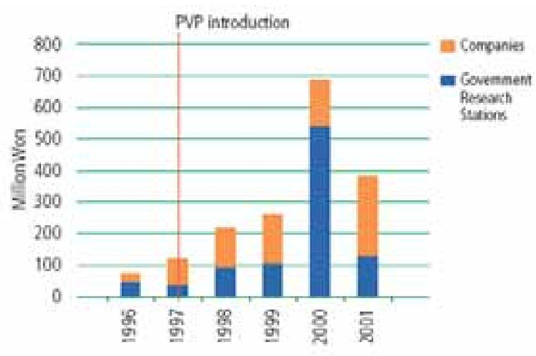
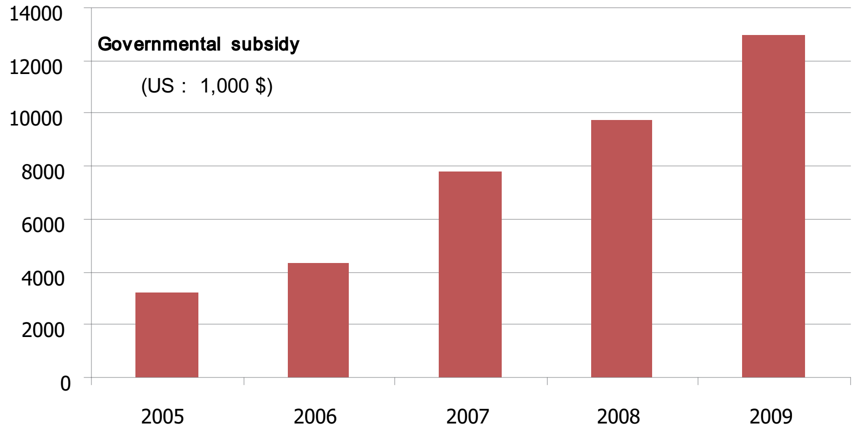


Fig. 11 Breeding Investment-Rose



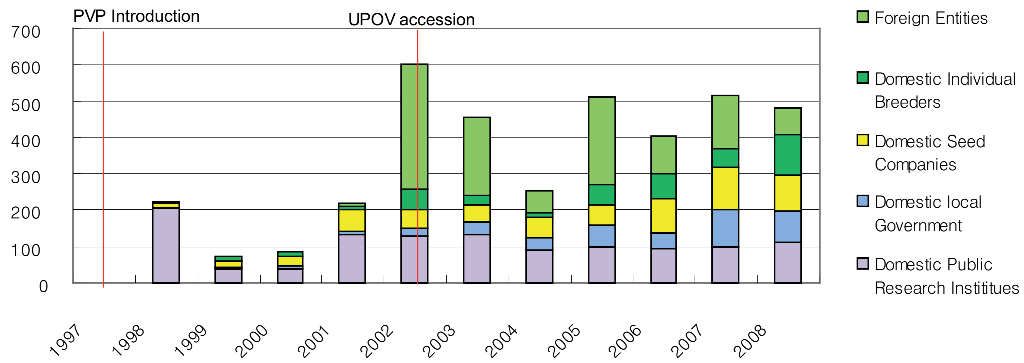
The Agricultural Research and Development Promotion Project is a scheme that provides matching funds for private investment, from 50 per cent to 75 per cent of the research cost, in agricultural technology research. As such, it is an indicator of the level of investment by the private sector. The project started in 1995, but breeders had difficulty in using the fund until 2004, because support was mainly focused on new technology for agriculture rather than new varieties. In 2006, the Government changed some of the criteria to support R&D and simplified the administrative procedures for breeders to use the fund. Fig. 12 shows the trend of investment by R&D matching funds for breeding new varieties.

Fig. 12 R&D Matching Fund Investment for Breeding New Varieties



(iii) Structure of the Breeding Industry

Fig. 13 Number of Applications by Category



The number of applications by category between 1998 and 2008 is provided in Fig. 13. The domestic central government category includes public research institutes, such as the National Institute of Crop Science (NICS), and the National Institute of Horticultural and Herbal Science (NIHHS). The domestic local government category includes the provincial crop stations. Foreign entities made a large number of applications after 2002 in particular for ornamental species.

The introduction of the PVP system encouraged many people to take an interest in breeding and, in the early stages, encouraged domestic PVP applications for most crops and foreign applications for ornamental crops.

Domestic seed companies have been mainly dependent on their own breeding programs or, in some cases. have cooperated with individual breeders. Since the introduction of the PVP system in the Republic of Korea, many university researchers have become interested in breeding commercial varieties (see Box 2, Rice "Sunong 6", "Sunong 8"). Also, for some crops, farmers (farmer-breeders) have shown an interest in breeding (see Box 10. Rice "Keumsung", Box 11, Lily "Dusan").

Box 10

Keumsung: Rice variety developed by a domestic individual breeder and granted protection in 2002

Box 11

Individual breeder KIM Yeong Hae (right)

Individual breeder AN Jae Yeong who bred lily variety "Dusan" which is PVP-registered and which won the Korean Top Variety Award in 2008.

The PVP system has encouraged local governmental research stations, universities and the Korean Atomic Energy Research Institute (KAERI, see Box 12) and KT&G (Korea Tobacco & Ginseng Corporation, see Box 5) to enhance their own breeding programs and distribution channels and new breeding segments have appeared. They are focusing on the niche market with the breeding of improved varieties with value-added traits. The availability of new, improved varieties has helped farmers to meet the increasing demand by consumers.

Box 12 Korea Atomic Energy Research Institute

Green Rice: "Nogwonchalbyeo"

"Nogwonchalbyeo" is a new, glutinous, green-kerneled rice (Oryza sativa L.) cultivar developed from native green-kerneled rice irradiated with 200Gy gamma rays. Compared to the original cultivar, "Nogwonchalbyeo" showed higher ripened grain ratio, early maturing characteristics, lodging tolerance and high yield (about 5.0 MT/ha in hulled grain rice). It also contains a higher amino-acid content than other conventional cultivars.

Ggoma (Hibiscus syriacu: Dwarf type cultivar "Ggoma" for potting culture and bonsai).

Government and public research institutes play an important role in the domestic breeding of fruit, ornamental crops and industrial crops.

(c) Foreign Investment/International Dimension

(i) Introduction of Foreign Varieties

Table 12 shows the development of the number of applications by non-residents (foreign breeders). It indicates a strong interest by foreign breeders in introducing their varieties into the Republic of Korea. Most of the varieties introduced by foreign breeders are ornamentals and their introduction coincides with the accession of the Republic of Korea to UPOV and the emergence of the flower business in the Republic of Korea.

Table 12 Number of Applications by Non-Residents by Crop (Top 10 Crops, 1998~2008)

	Crops	*No.*
1	Rose	487
2	Chrysanthemum	197
3	Kalanchoe	89
4	Gerbera	73
5	Anthrium	40
6	Carnation	36
7	Cymbidium	35
8	Impatiens	34
9	Pelargonium	30
10	Petunia	29
Total		1047
Total applications by non-residents		1169

Table 13 Number of Applications by Non-Residents by Crop (Top Five Crops)

	Agricultural		*Vegetables*		*Ornamental*	
	Crops	*No.*	*Crops*	*No.*	*Crops*	*No.*
1	Rice	1	Hot pepper	2	Rose	487
2	Soybean	1	Tomato	2	Chrysanthemum	197
3					Kalanchoe	89
4					Gerbera	70
5					Anthrium	40

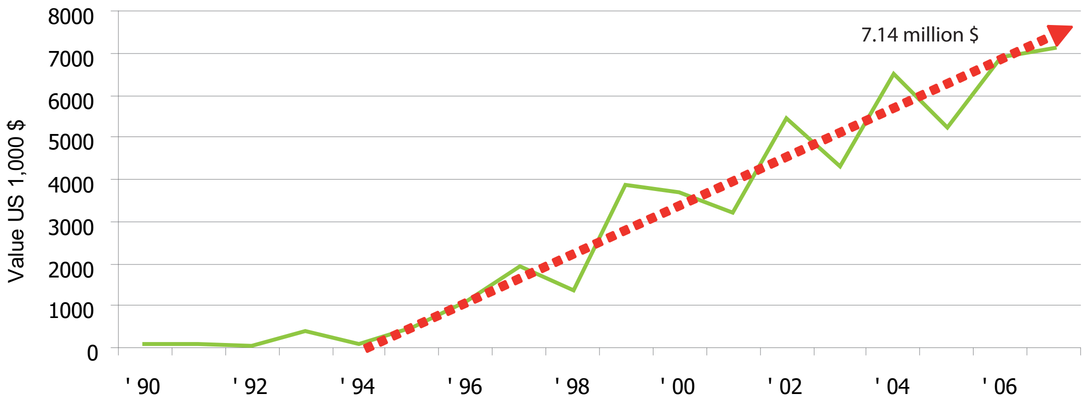
Table 14 Number of Applications by Country (Top 10 Countries, 1998~2008)

	Country	No
1	Netherlands	455
2	Japan	387
3	Germany	118
4	United States of America	65
5	Denmark	57
6	Italy	54
7	Israel	11
8	New Zealand	5
9	Spain	5
10	France	4
Total		1,161
Total applications by non-residents		1,169

(ii) Development of Foreign Markets

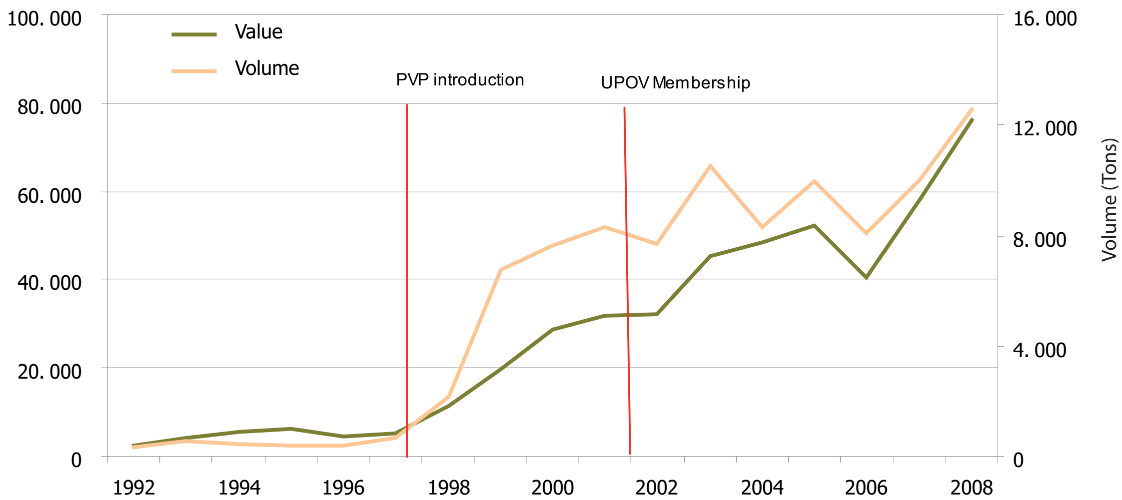
As shown in Fig. 13, the export of red hot pepper seed has increased consistently since 1995. There were competitive vegetable breeders even before the introduction of PVP and they were strong advocates of PVP. The introduction of PVP has accelerated the development of new varieties and led to an increase in the export of seed.

Fig. 13 Export of Red Hot Pepper Seed



The export of flowers and ornamental plants has been increasing since the late 1990s, coinciding with the introduction of PVP, which has supported an increase in the export of flowers and ornamental plants.

Fig. 14 Export of Flowers and Ornamental Plants (1000 US$ per Ton)



(iii) Breeder's Exemption

The UPOV system of PVP allows the use of protected varieties for breeding other varieties under the principle of the breeder's exemption. For example, protected foreign rose varieties may be used by breeders for further breeding purposes. In the case of the Republic of Korea, the increased investment in rose breeding, implied through the increased number of rose breeders and the increased rose germplasm resulting from the introduction of foreign rose varieties, should strengthen the rose-breeding sector in the country (see Box 13).

Box 13

"Ruigerdan" (Little Marble)
Developed in the Netherlands

"Little Sun" (Bright red variety)
Rural Development Administration
Developed at the Kyungnam Provincial
Crossing of: Nikida × Little Marble

Korean rose variety "Little Sun", granted protection in 2006, was bred using the protected variety "Ruigerdan" (Little Marble), developed in the Netherlands *(d) Summary*

The introduction of PVP in the Republic of Korea in 1997 and membership of UPOV in 2002 have had a significant influence on the seed and breeding industries.

Although it is still premature to evaluate the full impact, the following effects have been observed.

- Introduction of PVP resulted in a large number of new varieties by residents. Membership of UPOV was associated with a large number of new varieties by non-residents, particularly in the ornamental sector.
- An instant response to the extension of the range of genera and species covered by PVP could be observed by the sharp increase in the number of PVP right applications in ornamental crops in July 2001.
- New, improved varieties have been produced for various agricultural and horticultural corps, including traditional crops (e.g. ginseng).
- Introduction of new foreign varieties, especially ornamental varieties such as roses, have contributed to the flower industry of the Republic of Korea, one of the fastest developing sectors of agriculture in the country; introduced varieties have been used by domestic breeders for further breeding; the PVP system has also supported the export of flowers and ornamental crops.
- There is a continuous increase in the number of applications from the private sector and local governments, but the number of applications by central government is relatively stable.
- The PVP system has stimulated certain sectors in plant breeding: in the sector of ornamental breeding, new breeders have appeared and the number of domestic varieties has increased; in the sector of vegetable breeding, private companies have continued their major roles in breeding for domestic distribution or seed export.

6. Conclusions

We have seen the experience of the Republic of Korea in meeting several challenges by encouraging plant breeding through the introduction of PVP and accession to the UPOV Convention.

After the introduction of the PVP system and accession to the UPOV Convention, breeders could work more effectively and there has been development in the breeding industry. The Government of the Republic of Korea also considers the breeding industry as a key sector of agriculture and has been promoting investment by an R&D matching fund, etc.

As a result of breeding, there has been improvement of varieties; farmers have access to better varieties.

As shown in the export of red hot pepper seed, cut flowers and ornamental plants, PVP has facilitated export by improvement of varieties or supported it.

ANNEX NUMBER OF GENERA AND SPECIES DESIGNATED TO BE ENTITLED TO PROTECTION.

Eligible for protection since	*Genera and species*
December 31, 1997 (27 genera/species)	▪ Food Crops (6): Rice, Barley, Soybean, Maize, Potato, Wheat ▪ Vegetables (14): Radish, Chinese cabbage, Cabbage, Pepper, Tomato, Cucumber, Oriental melon, Water melon, Squash, Welsh onion, Onion, Carrot, Lettuce, Spinach ▪ Fruit (3): Apple, Pear, Peach ▪ Ornamentals (1): Plain cactus ▪ Feed crops (3): Rye grass, Tallfescue, Red clover
May 1, 2000 (30)	▪ Food Crops (2): Oats, Sweet potato ▪ Vegetables (2): Melon, Cauliflower ▪ Fruit (2): Grapevine, Yuzu (Citrus) ▪ Ornamentals (15): Forsythia, Hibiscus, Lycoris, *Ajuga multiflora*, *Lisianthus*, Petunia, Godetia, Impatiens, Cyclamen, Snapdragon, Pansy, Daisy, Alstromeria, Hyacinth ▪ Industrial crops (7): Sesame, Perilla, Ground nut, Rape, *Angelica gigas*, *Astragalus membranaceus*, Mushroom (Pleurotus spp.) ▪ Feed crops and others (2): Orchard grass, Ginseng
July 1, 2001 (31)	▪ Ornamentals (21): Dendrobium, *Aerides japonicum, Neofinettia falcata*, Calanthe discolor, Rose, Lily, Chrysanthemum, Iris, Gladiolus, Tulip, Poinsettia, Celosia, Stock, Zinnia, Forget-me-not, Cineraria, Nasturtium, Pot marigold, Sweet alyssum, Ageratum, Day lily ▪ Industrial crops (10): *Rehmannia glutinosa*, Lycium, Dioscorea, *Bupleurum falcatum*, *Platycodon grandiflorum*, Cassia, *Liriope platyphylla, Anglica dahurica*, Saposhnikovia
July 1, 2002 (25)	▪ Food Crops (4): Rye, Adzuki bean, Mungbean, Pea ▪ Vegetables (3): Egg plant, Pak choi, Gourd ▪ Fruit (1): Kiwi fruit ▪ Ornamentals (9): Kalanchoe, Cattleya, *Oncidium*, Plantain lily, Canterberry bells, Geranium, Bird-of-paradise, Tree peony, *Chamaecereus silvestrii* ▪ Industrial crops (8): Ganoderma, Angelica koreana, *Pleuropterus multiflorus*, Alisma, *Scutellaria baicalensis*, Chinese peony, Carthamus tinctotius, Lance Asia bess
December 1, 2004 (42)	▪ Food Crops (2): Kidney bean, Job's tears ▪ Vegetables (4): Mustard, Turnip rape, Kohlrabi, Edible chrysanthemum ▪ Ornamentals (31): Dahlia, Allium, Fritillary, Gloxinia, Common calla, Blue grape hyacinth, *Ornithogalum, Anthurium*, Crocus, Amaryllis, Royal azalea, Common camellia, Hydrangea, Carnation, Gerbera, Gypsophila, Kaffir lily, Sea lavender, Begonia, Bachelor's button, Moth orchid, Aquilegia, *Campanula punctata*, Campanula takesimana, Rough gentian, Gentiana, Aster, Spring orchid, Winter orchid, Chinese pink, Freesia ▪ Industrial crops (5) : *Schizandra, Angelica*, Atractylis, Cnidium, mushroom (*Phellinus spp*.)
December 1, 2006 (34)	▪ Food Crops (2): Buckwheat, Triticale ▪ Vegetables (7): Chinese chive, Kale, Leaf beet, Whorled mallow, Chicory, Endive ▪ Ornamentals (17): Thistle, Delphinium, Phlox, Indian rubber tree, Dracaena fragrans, Philodendron, Tillandsia, Cymbidium, Anemone, Clematis, Lantana, Gay-feather, Desert rose, Maindenhair fern, Osmunda, Dracaena, Peperomia, Indian fig cactus ▪ Industrial and Feed crops (8): Fatsia, Codonopsis, Cyperus, Common Anemarrhena, Gardenia, Entomopathogenic fungi, Hawthornleaf raspberry, Alfalfa
March 1, 2008 (34)	▪ Food Crops (3): Italian millet, Common millet, Sorghum ▪ Vegetables (3): Celery, Parsley, *Brassica rapa* L ▪ Ornamentals (9): *Hedyotis diffusa* Willd., *Euphorbia hypericifolia*, Alocasia, Exacum, *Aster koraiensis* Nakai, Gaura, Tickseed, *Sedum kamtschaticum*, *Carex okamotoi*, ▪ Industrial crops (5): Chinese licorice, Eucommia (Gutta-percha tree), Asiatic dogwood (Japanese cornel, Japanese corneliancherry), *Gastrodia elata* Blume, Japanese mugwort ▪ Mushrooms (3): *Agaricus bisporus* Sing, Winter mushroom (Enokitake, Velvet footed Collybia), Shiitake ▪ Trees (11): Persimmon, Japanese plum, Apricot, Mume (Japanese Apricot), *Mukdenia rossii*, Chestnut, Zelkova, Hill cherry (Japanese mountain cherry), ACER PALMATUM Thunb. ex Murray, Jujube, Tobacco
May 1, 2009	All Species and Genera except for Strawberry, Raspberry, Blueberry, Mandarin, Cherry and Seaweed

DISCUSSION

EUNICE OMBACHI (KENYA SEED COMPANY LTD., KENYA): I didn't really understand whether you have an organization that is in charge of plant variety rights. Secondly, do you have a body that arbitrates if there is a contest about somebody wanting to protect a variety that is really close to an existing variety? How do you arbitrate?

CHANG HYUN KIM: There are two PVP offices in the Republic of Korea that are responsible for plant breeders' rights. Regarding agricultural plants, the Korea Seed and Variety Service (KSVS) is responsible for plant breeders' rights. With regard to arbitration, the Government strongly encourages parties to go to arbitration before they start a judicial procedure. However, if they cannot resolve the situation by arbitration, they must go through the judicial procedure.

PATRICK NGWEDIAGI (MINISTRY OF FOOD SECURITY AND COOPERATIVES, UNITED REPUBLIC OF TANZANIA): I am very impressed by the efforts of your Government to encourage breeding. So I would like you to shed more light on the efforts of the Government, especially on this system of giving awards to breeders.

DOUG WATERHOUSE: We all share your positive view of giving awards to breeders. Now we can move towards the general discussion on this topic.

General Discussion

MANOJ SRIVASTAVA, PPV AND FR AUTHORITY, MINISTRY OF AGRICULTURE, GOVERNMENT OF INDIA The farmer plays an important role in conserving the plant genetic resources. Do we give any privileges or benefit to the farmers who have developed this material for so long by tradition, because that material is used by the breeders in various countries for developing new varieties?

ROLF JÖRDENS: The advantage and the objective of the system are, of course, to provide farmers and growers with more and better varieties. A farmer's privilege, as such, does not exist in the UPOV Convention. We have a number of exceptions and I think Peter Button explained these compulsory exceptions; in particular, the exception which allows the use of the protected variety for private and non-commercial purposes, and that concerns subsistence farmers – as long as their activities are private and non-commercial. That is a compulsory exception in the UPOV Convention, which perhaps concerns more than 50 per cent of the farmers in many developing countries. So they would not be subject to any restriction and could use a protected variety for private and non-commercial purposes. Then there is the optional exception, which means that a UPOV member may restrict the scope of the breeder's right in order to allow farmers to reproduce a variety from the harvest of a protected variety on their own farm or holding. This optional exception allows many different forms of restricting or limiting the breeder's right, according to specific circumstances in a particular country. It is very difficult to summarize this here, but there are many possibilities and examples of how UPOV members have made use of this optional exception. As I think we stressed here, we should not forget that the objective is of course to encourage breeding, to encourage the introduction of new and better varieties – that is the objective and here governments need to be very cautious not to undermine, or to forget, the overall objective of the system. I think that is what we need to keep in mind.

FRANÇOIS BURGAUD (GNIS, FRANCE): I would like to go back to the remark of the representative of Syngenta about the position of Plantum, because I am not totally sure that the answer of Plantum is a 100 per cent good answer, but I am quite sure that it is a good question. It is a good question for two main reasons: firstly, some patent claims from seed and biotech companies are not reasonable and, secondly, the policies of patent officers indicate a misunderstanding about plant-breeding activities. The representative of Syngenta talked about balance. I see clearly in UPOV and plant breeders' rights the balance between an exclusive right on production and sale and free access for further breeding activity, so I would like to know what is the second part of the balance in the patents on biotech inventions.

LEO MELCHERS (SYNGENTA SEEDS B.V., NETHERLANDS): The purpose of patenting of biotechnological inventions is very different from plant breeders' rights. We are talking about molecular breeding, investments which have been made by the breeder, high investments, to discover novel traits and we are talking about a system of rewarding the plant innovator, the innovator of traits. It is not about blocking access, it's about using the patent system, which has a role in the seed industry. Parties can get access to licenses and use these traits in their breeding program and that is where we look for a balanced approach in terms of value-sharing between the innovator, the licensee and also, definitely, the farmer who will benefit from the innovation and will have better crops to grow, and will also have a higher income from using improved varieties.

DOUG WATERHOUSE: One of the issues that we didn't air today, of which François has just reminded me, was a key factor in the UPOV system, and that is about certainty. One of the very nice things is the idea of exhaustion. Instead of having an implied exhaustion as for some other rights, the UPOV system has an explicit and total exhaustion once the breeder has sold material or material has been sold with his consent, provided some other particular circumstances don't arise further on. So that is another part of the balance, once material is sold to the farmer, then the plant breeder's right is completely exhausted.

ANTON VAN DOORNMALEN (RIJK ZWAAN ZAADTEELT EN ZAADHANDEL B.V, NETHERLANDS/MEMBER OF THE BOARD OF PLANTUM NL): I would like to say that Plantum very much supports the PVP system and especially the breeder's exemption. We would like here, especially, to underline that we are not against patents. We see that patents are a very good means to protect breeding matters and technologies. However, we see that more and more traits are patented, and we are of the opinion that when a patented trait is in a new variety, or when a variety is made by a patented technique or method, then that variety should be protected by a plant breeder's right and should have full breeder's exemption; the full breeder's exemption should be applicable, which means that the whole variety, with all its characteristics should be freely available for all breeders. In other words, if we accept that one patented trait is indirectly patenting the variety, the breeder's exemption becomes worthless, and, with that, the plant variety protection system. That is what we are discussing and that is, in fact, the new standpoint of Plantum.

LUCA COLOMBO (GENETIC RIGHTS FOUNDATION, ITALY): I am interested in understanding the evolution of the UPOV system, if any, in the near future, with particular reference to the exceptions – both currently compulsory and optional.

ROLF JÖRDENS: We expect further growth in UPOV membership: on average, UPOV has seen three new members per year. So that is what I see in the first place as an evolution of the UPOV system. I think your question concerns the UPOV Convention and I think it is a question which should be addressed to the President of the Council of UPOV. Of course the UPOV Office follows this matter and I can only say for the moment, and I think the President can probably confirm, that there is no indication that UPOV members have taken any initiative with regard to revision of the 1991 Act of the UPOV Convention.

DOUG WATERHOUSE: That is correct. There have been no instructions from the Council in relation to any developments in the Convention.

JOHN HAMPTON (BIO-PROTECTION RESEARCH CENTRE, NEW ZEALAND): When Peter answered the question before about distinctness, he more or less implied that you were looking at morphological characteristics. How do you address a situation where the distinctness is due to the presence of a microbe in association with the plant, for example, a fungal entophyte?

PETER BUTTON: I think we have to be a little bit careful that we split that up because there are two issues: firstly, to do with plant variety in a traditional plant variety sense, but you also seem to be talking about the fungal entophyte itself as potentially covered by the UPOV Convention - the definition of plant can be broad in the UPOV Convention and whether fungi, bacteria, algae and so on are covered by the UPOV Convention is a matter for each UPOV member to consider. You can then look at the fungal entophyte in its own right if you decide to offer protection for that. However, if you are looking at the plant, ignoring the endophyte for a moment, then it is the plant variety that has to be distinct. It cannot be considered as a different plant variety because you have infected it with a disease or an organism; that doesn't make it a different plant variety. There are some difficult situations where, for example, organisms such as phytoplasma can have an influence on the plant and you have to be very careful to check if the difference is in the plant variety and not an infection that has taken place. You can also consider protecting fungal endophytes. Certainly I know that some UPOV members are looking very closely at that. That must be separated from looking at the "traditional green plant" where we must be careful to check if we are looking at a different variety rather than the same variety which looks different because it is infected by an organism.

TRUDY WERRY (CANADIAN FOOD INSPECTION AGENCY, CANADA): My question is also on the criteria of distinctness in relation to a plant breeder's right. Is distinctness only based on phenotype, or is UPOV moving towards molecular techniques? What happens if molecular techniques are used to show distinctness in crops, such as potatoes where it is very hard to see any difference from variety to variety, even though they are different?

PETER BUTTON: This is another area where there is a lot of discussion within UPOV – the potential use of molecular techniques in the DUS examination. I think the first thing to say, and probably we always start with this, is that at the moment we have a very effective and efficient system of DUS examination. It works very well and is a very costfective system. So we are not under urgent pressure to introduce new techniques to solve a problem. However, there are new techniques, and potentially they can assist in the DUS examination. At the same time, a major concern of breeders, which has been communicated to UPOV, is that if you use these techniques to find very, very small differences between varieties, potentially down to just one base pair, there is a risk of undermining the value of protection. Potentially, the result could be a very large number of essentially derived varieties, differing only by one base pair. Nevertheless, there are ways in which molecular techniques might have potential to make the system more efficient. Those are under discussion in UPOV. Already there are some approaches that have been agreed. For example, a test for a molecular marker reliably indicating the presence of a phenotypic expression - for example, a particular disease-resistance - could be used instead of the phenotypic test. There you are not really changing the DUS criteria, but you are making the test more efficient – you are checking to see whether the gene is there. There are also broader approaches for using molecular markers to screen the varieties of common knowledge to try to help to ensure that we identify the most similar varieties and to ensure that they are included in the DUS growing trial, but this is quite a complex area and, again, it needs some safeguards built into it. We have some documents that explain where we are on all of this. It is an area that we are looking at, but I think what everyone is very concerned about is that we don't lose the value of the current system of plant variety protection, nor its effectiveness. We don't want to just switch over to a new system for no benefit and potentially to undermine the value of protection that we have already.

NICK DOWNEY (EUROPEAN MOBILE SEED PROCESSORS ASSOCIATION): Did I understand from the earlier question of my colleague that the optional farm-saved seed exemption in Europe is not under review?

DOUG WATERHOUSE: We have the President of the Community Plant Variety Office of the European Community (CPVO), Mr. Bart Kiewiet, with us. Perhaps he could answer that.

BART KIEWIET (COMMUNITY PLANT VARIETY OFFICE OF THE EUROPEAN COMMUNITY (CPVO)): At the moment, there is no official review of the farm-saved seed provision in the framework of the Community plant variety system. There has been a study initiated by the CPVO to try to have a picture of the present situation and to try to clarify whether the present provision is effective and whether it serves its aims. We are in the process of further studying the situation and it might lead to proposals of a revision of the actual provision as regards farm-saved seed. But, at the moment, an official review is not taking place. We are in the phase before an official review.

Session 3. Conclusion, presented by the Chairperson
Plant Variety Protection

- The number of new varieties increased after the introduction of plant variety protection.

- Introduction of the UPOV system of plant variety protection was associated with increased breeding activity and with the encouragement of new types of breeders, such as private breeders, researchers and farmer-breeders.The introduction of PVP was also associated with the development of partnerships, including public-private cooperation.

- Introduction of plant variety protection was associated with the development of new, protected varieties that provided improvements for farmers, growers, industry and consumers, with overall economic benefits.

- One of the benefits of plant variety protection is to encourage the development of new, improved plant varieties that lead to improved competitiveness in foreign markets and to development of the rural economy.

- Membership of UPOV was associated with an increase in the number of varieties introduced by foreign breeders, particularly in the ornamental sector.

- The breeder's exemption, whereby protected plant varieties can be freely used for further plant breeding, is an important feature of the UPOV system which advances progress in plant breeding.

- Access to foreign plant varieties is an important form of technology transfer that can also lead to enhanced domestic breeding programs.

Session 4

THE IMPORTANCE OF QUALITY SEED IN AGRICULTURE

Chairperson: Mrs. KATALIN ERTSEY, President of the International Seed Testing Association (ISTA) and Director plant production and horticulture, Central Agriculture Office (OMMI) (Hungary)

- **What is seed quality and how to measure it?**
  Mrs. ALISON POWELL, Honorary Senior Lecturer, University of Aberdeen (United Kingdom)

- **The influence of seed quality on crop productivity**
  Mrs. RITA ZECCHINELLI, Head of ENSE Seed Testing Laboratory, Tavazzano (Italy)

- **The evolution of seed testing**
  Mr. MICHAEL MUSCHICK, Secretary General, ISTA

- **Building capacity in seed quality assurance in developing countries**
  Mr. MICHAEL LARINDE, Senior Agricultural Officer (Seed Production), Plant Production and Protection Division (AGP), Agriculture and Consumer Protection Department, FAO

- **Raising seed quality: what is in the pipeline?**
  Mr. JOOST VAN DER BURG, Seed scientist, Agrosystems Research, Plant Research International (Netherlands)

- **Maintaining capacity in seed technology and seed testing**
  Mr. JOHN HAMPTON, Director Bio Protection and Ecology Division, Professor of Seed Technology, Lincoln University (New Zealand)

General discussion

Conclusion, presented by the Chairperson

WHAT IS SEED QUALITY AND HOW TO MEASURE IT?

Mrs. ALISON A POWELL*

Introduction

Throughout the world, farmers and growers have clear demands of the seeds that they sow. Firstly, they want the species and variety to be consistent with what they believe they have bought. Secondly they want that seed to achieve uniform and successful establishment of a weed-free crop that will develop without the incidence of diseases that result from seed-borne infection. Achievement of these requirements is assisted by the methodologies of seed quality testing that are developed and standardized by the International Seed Testing Association. These seed-testing methods can be used during seed production and marketing to ensure that seed quality is maintained. This paper will consider the different testing methods that are available to help fulfill the requirements of farmers and growers.

The first two aspects of seed testing to consider, variety and purity testing, are those that ensure that a farmer sows the species and variety he wants without contamination with weed seeds or seeds of other crop species. A point to be made at the outset is that all tests are done on samples drawn from the seed lot, which is the population that will be sown. Methods for seed sampling are described in the ISTA Rules for Seed Testing (ISTA, 2009a), with further background and detail in the ISTA Handbook on Seed Sampling (ISTA, 2004).

Variety Testing

There are two aspects to variety testing. The first is to ensure that a sample is the required species or variety and the second to ensure the purity of the variety, that is, that the variety is not contaminated by the seed of other varieties. Varietal purity can mean checking whether a variety is, for example, completely of the F1 variety it is claimed to be, or whether a conventional variety is contaminated by GM seeds or vice versa. Traditional methods of variety testing include morphological methods. In such methods the characteristics of the seeds may be compared; for example, differences in seed color may reveal that varieties have been mixed. Alternatively the characteristics of seedlings may be observed in the laboratory or in the field, or other plant or fruit characteristics may be observed in the field.

More modern methods of variety testing can involve a range of biochemical and molecular techniques. Biochemical methods include analysis of the protein reserves of the seeds by electrophoresis, an approach useful in the comparison of F1 hybrids and the parental lines. Molecular methods include the use of molecular markers. These methods involve extraction of the DNA and the polymerase chain reaction (PCR) in which selected DNA is multiplied. Another approach is the use of microsatellites and single sequence repeats (SSRs).

Detection of genetically modified seed material is an area of seed testing that has aroused considerable interest and debate over the last few years. Many methods have been employed including bioassays, protein-based methods such as ELISA and DNA-based methods, specifically end-point and real-time PCR.

Analytical Purity

The analysis of the analytical purity of the seed examines the extent to which a seed sample is contaminated with other seeds (weeds and other crops) and other plant and inert material. It therefore reveals the extent to which the seed that a farmer buys is actually the desired seed.

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The methods of purity analysis involve observation of seed samples using lenses and microscopes and separation of the seed into different portions. Hand lenses or binocular microscopes help identification and separation of small seed units and fractions of seed; sieves may be used to separate trash, soil, small pieces of seed and other small particles; blowers remove light material such as chaff and empty florets from grass seed samples. The test result for analytical purity reveals the percentage by weight of pure seed that is present in a sample, the other seeds (which are identified) and the inert material.

Assuming that the seed is the correct variety, the farmer now wants it to achieve a uniform and successful establishment. Two aspects of seed quality influence this, the ability of seed to germinate and the seed vigor. The germination of a seed sample is most commonly assessed in germination tests, although if a rapid assessment of potential germination (viability) is required, a tetrazolium test may be used.

Germination Tests

The aim of a germination test is to provide ideal conditions for germination so that the maximum potential of the seed is revealed. The ideal conditions for germination of different species may differ in terms of the substrate, temperature and time. The substrate for germination may be sand, an organic medium, on top of paper or between papers. Temperatures for germination are either constant or alternating, where one temperature is applied for a specified length of time, followed by another temperature for the rest of a 24-hour period. Finally the time allowed for germination in agricultural and vegetable species can range from as short as five days for jute (Cochorus olitorius and C. sativum) to as long as 28 days for Panicum maximum (guinea grass) and 35 days for Tetragonia tetragonoides (New Zealand spinach). The germination requirements for seeds of over 320 agricultural and vegetable species, 190 tree and shrub species and 350 flower species are found in the ISTA Rules for Seed Testing (ISTA, 2009a).

Another characteristic of seed to be considered in a germination test is seed dormancy. In many plant species the presence of dormancy means that the viable seeds will not germinate even when the ideal conditions are present unless they have received a specific environmental cue. This evolutionary trait is a survival strategy which ensures that seed will only germinate when the environmental conditions are suitable for seedling growth and plant establishment and also spreads the germination over a period of time. There are detailed descriptions of different types of dormancy (Baskin and Baskin, 2000), but they can be simply described as being of two types, physiological and physical. Thus, in addition to the requirements for a germination test, the pre-treatments necessary to break the dormancy of many species have also been identified. Treatments to break physiological dormancy include dry storage, which usually applies to species that have a short period of dormancy; moist pre-chilling, usually at temperatures of 5-10oC for agricultural and vegetable seed and 1-5oC for tree seeds; pre-heating; light; and potassium nitrate or gibberellic acid provided during germination. Physical dormancy arises due to a hard seed coat that prevents the uptake of water at the beginning of germination. This so-called ‘hard-seededness’ can be broken by soaking in water for 24-48 hours, mechanical scarification or acid scarification.

The treatments required to break dormancy before or during a germination test are also given in the ISTA Rules (ISTA 2009a). Dormancy is not often seen in many crops, having been selected out by the act of cultivation over thousands of years. There can be problems however in years when the weather causes problems during harvest or in species brought into cultivation more recently

At the end of a germination test, a seed is said to have germinated successfully if it has developed to the stage where the appearance of the seedling indicates whether or not it is able to produce a satisfactory plant in favorable field conditions. Such a seedling is described as a normal seedling. If a normal seedling is not produced, the seedling is described as abnormal and would not be expected to produce a plant in the field. The result of a germination test is reported as a percentage of normal seedlings, abnormal seedlings, hard (unimbibed), fresh (i.e. moist but firm) and dead seeds (ISTA, 2009a).

Tetrazolium Tests

The tetrazolium test is a biochemical test that provides a rapid assessment of the viability of the seed by assessing the degree to which the tissue of the embryo of the seed is living by using a stain. The stain used is 2, 3, 5 triphenyl tetrazolium chloride, which reacts with active respiratory enzymes in the seed tissue to produce a red color. Thus, if a tissue stains red, it is living. Work over many years has identified the extent to which different tissues in the seed of many species must be alive to enable the production of a normal seed. The essential structures for germination should be stained in a viable seed, but, experience has shown that, depending on the species, small amounts of dead tissue are acceptable even on these parts of the seed. Assessment of a whole seed sample gives percentage viability for a seed lot.

The tetrazolium test is particularly useful in cases where a rapid assessment of the viability of a seed lot is required and a germination test would take too long. This may be when seeds have to be sown soon after harvest, in seeds with deep dormancy, when seeds show very slow germination, or when a very quick estimate of the germination potential is required. It can also be useful at the end of a germination test to determine the viability of seeds that have failed to germinate and may be dormant but not dead. The test is used to detect damage during harvesting and processing, such as heat and mechanical damage, and has been used to help develop less-damaging production techniques.

Specific details of preparation of the seed, stain concentration and time and temperature of staining can be found in the ISTA Rules (ISTA 2009a), with further information in the ISTA Working Sheets on Tetrazolium Testing (ISTA, 2007a, b).

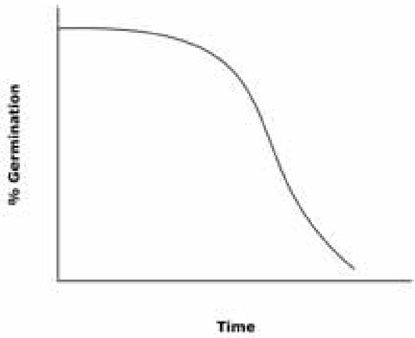
Vigor Tests

Germination tests are the primary assessment of the ability of seed to germinate and emerge in the field. However, although the results of the standard germination test give a good correlation between germination and field emergence in favorable conditions, germination can fail to indicate the ability of a seed lot to establish a crop in poor field conditions, for example, cold, wet soils. There have been instances described in a wide range of species where seed lots having equally high laboratory germinations show wide differences in field emergence. This has been shown to be a problem in a number of species, including grain legumes (Powell et al., 1984); small seeded vegetable species, (Matthews, 1980); a range of vegetables and cucurbit species (Perry, 1973); sugar beet (Perry, 1973; Akeson and Widner, 1980; Matthews, 1980); maize (Nijenstein, 1986; Bekendam et al., 1987; Lovato and Balboni, 1997).

This failure of the germination test to predict differences in field emergence, particularly in poor field conditions, suggested that there is a further physiological aspect to seed quality, which has come to be referred to as seed vigor (ISTA, 1995). Seed lots having high germination, but poor emergence are referred to as low-vigor seeds, whereas those giving good emergence are termed high-vigor seeds. Vigor is also reflected in the rate of germination and seedling growth, in both favorable and unfavorable conditions for germination and emergence. Low-vigor seeds germinate slowly over a long period of time to produce a range of seedling sizes, whereas high vigor seeds germinate rapidly and synchronously to produce large and uniform seedlings. Furthermore, high vigor seeds have good storage potential while low vigor seeds lose the ability to germinate more rapidly during the storage period.

Differences in the vigor of germinable seed can be explained by the process of seed aging. The seed survival curve (Fig. 1) shows the changes in germination of a seed lot over a period of time. There is a long period when germination falls only slowly but during which seeds are aging. Subsequently the incidence of death in the seed population increases and the percentage germination falls rapidly. Vigor differences arise due to the position of a seed lot on the slow decline in germination. A seed lot at the beginning of the decline is physiologically young and has high vigor; a lot at the end of the decline is physiologically old and has low vigor.

Fig. 1 The seed survival curve



Tests to identify differences in seed vigor exploit the fact that aging is the major cause of vigor differences. This is the case for the two tests that are currently in the ISTA Rules (ISTA, 2009a). The electrical conductivity test measures the leakage of solutes from seeds of Pisum sativum and Phaseolus vulgaris, with low-vigor (aged) seeds showing high levels of leakage in comparison with high-vigor seeds. The accelerated aging test for Glycine max (ISTA 2009a) and the controlled deterioration test for Brassica spp.(which will appear in the ISTA Rules 2010) subject a sample of seed to an additional period of aging to determine the initial position of the seed on the survival curve and hence its vigor.

The results of a vigor test give a farmer more information about the potential of a seed to perform in a range of soil conditions; a seed company information for managing its seed stocks, both in store and in marketing; a seed producer guidance regarding where seed quality may be reduced and how this can be minimized.

Seed Health Tests

Seed health tests to detect whether seeds are contaminated with or infected by a plant pathogen are important for a number of reasons. The presence of seed-borne inoculum may cause disease within a crop giving an opportunity for very rapid spread of disease, may introduce a new disease into new regions or countries and may reduce the germination of seeds by reducing the percentage of normal seedlings produced. In addition, the results of testing can indicate the need for seed treatments.

The term "seed health" includes the incidence in the seed lot of fungi, bacteria, viruses, and animal pests such as nematodes and insects. The test used depends on the organism being tested for and the purpose of the test quality assurance or phytosanitary purposes when seed is exported.

Methods of seed-health testing range from direct visual observation to highly sophisticated tests. Direct examination of the seed may be enough to identify an infected lot if diseased seeds are clearly discolored or have an uneven shape. Alternatively pathogen structures such as fruiting bodies may be identifiable from direct examination, or washing of the seed can remove fungal spores from the surface and enable identification, e.g. spores of Ustilago nuda (loose smut).

A further common method of testing is incubation of the seed on moist germination paper or a nutrient medium to allow growth of the pathogen and subsequent identification. Fungi may be identified by their fruiting bodies and color of their growth (the mycelium), bacteria by the color, shape and texture of their colonies. An extension of this approach to health testing is the grow-out test whereby seeds are allowed to germinate and the seedlings are examined for symptoms of infection.

Immunoassays present a more sophisticated approach to testing, with Enzyme Linked Immunosorbent Assays (ELISA) and immunofluorescence being most common. In ELISA tests, an antibody to a specific protein (antigen) in the pathogen is added to a sample and the reaction between them reflected in a color change which indicates infection. For example, soybean mosaic virus, bean pod mottle and other viruses can be detected using ELISA.

Finally there are DNA-based molecular techniques, the most common being the polymerase chain reaction (PCR), which selectively increases pathogen DNA. Electrophoresis is then used to separate the

DNA into different sizes, followed by staining. The incidence of pathogen DNA can be identified by comparisons with known samples.

The Annex to Chapter 7 (Seed Health) of the ISTA Rules (ISTA, 2009b) describes the 25 seed-health testing methods that have been validated by ISTA.

Seed Moisture Content

The moisture content (MC) of the seed is an additional characteristic that does not have an immediate, direct effect on quality, but is highly important. Tests of seed MC fulfill three main purposes. Firstly to prepare the seed for long- and short-term storage, secondly, the seed MC will influence the price paid for a weight of seed and thirdly the MC will determine the response of seeds to dormancy-breaking techniques and vigor tests.

The most significant effect of MC is on the rate of seed aging and hence the rate of decline in seed quality during storage. Thus, as the seed MC increases, the rate of aging also increases. As a rough guide, Harrington (1960) suggested that an increase in seed MC of 1% will double the rate at which germination declines. The MC therefore influences the time period over which the seed survival curve (Fig. 1) takes place. During storage the MC of the seed moves into equilibrium with the relative humidity (RH) of the store, therefore the RH during storage has a crucial effect on the MC and seed aging. In addition the storage temperature affects the rate of aging, with an increase of 5o C doubling the rate of aging (Harrington, 1960). The impact of MC and temperature on seed quality are therefore of particular significance in tropical countries where ambient conditions will tend to lead to rapid loss in seed quality. Inexpensive methods of storing seeds to minimize this decline in quality are therefore needed in areas where food security may be a problem.

An increase in the storage RH not only leads to more rapid seed aging, but the activity of saprophytic fungi, insects and mites also increases as the RH and seed MC increase. Thus the growth of the fungus Aspergillus will begin at 65-85% RH, Penicillium at >80% RH and Alternaria at >90% RH. The growth of these fungi leads to a further increase in seed MC and an increase in temperature, both of which enhance the rate of deterioration. In addition, they produce toxins that destroy cells which then provide the substrate for fungal growth. When seed MC increases to 15% and above, the activity of weevils, flour beetles and seed borers also increases. This places emphasis on the importance of storage conditions to maintain the seed MC and also minimize activity of storage fungi and pests.

Seed-moisture content is assessed by the removal of water though heating either the intact seed or after grinding. Comparison of the seed weight before and after heating gives the weight of water in the seed which is expressed as a percentage of the initial seed weight. This process can also be completed automatically by using one of many moisture meters that are available, although it is important that such meters are accurate and calibrated at least once each year

Uniformity in Seed Testing

ISTA's vision is to have uniformity in seed testing, since this leads to the repeatability of results within a laboratory and reproducibility of results when different laboratories test the same samples. The successful fulfillment of this vision means that there can be confidence in the information provided by seed testing to give reassurance to those in the seed trade and the end user. Work towards ISTA's fulfillment of this vision is achieved in three main ways.

Firstly, there are the ISTA publications. The International Rules for Seed Testing (ISTA 2009a) provide detailed protocols for the completion of methods that have been accepted into the Rules as being fit for purpose and giving repeatable and reproducible results. The Rules are supported by a range of ISTA Handbooks, produced by the different Technical Committees. The Handbooks provide additional background to the tests and also further information that helps in their completion. For example, the Seedling Evaluation Handbook, includes diagrams and photographs of normal and abnormal seedlings to assist in their identification in the germination test and the Handbook on Moisture Determination

(ISTA, 2007) gives details about the importance and role of water in seeds, the importance of MC in other tests and guidance on the completion of the test.

Secondly, workshops and seminars are organized by the Technical Committees. These enable participants to learn from experts in each topic, more about specific tests or testing particular groups of species and to complete practical work. Face-to-face discussion both with the experts and other seed analysts from many countries provides a stimulating and informative experience. Furthermore, since attendance at the workshops and seminars is not limited to ISTA members, non-members can attend and begin to learn more about the importance of aspects of seed quality and methods of testing.

Thirdly, the ability of laboratories to satisfactorily complete specific aspects of seed testing on defined species is recognized by ISTA though the accreditation of laboratories. This means that the laboratories are audited regularly by both systems and technical auditors to ensure that ISTA methods are being applied correctly. Accredited laboratories must also participate in proficiency testing. This involves all the accredited laboratories testing the same samples and analysis of the resulting data to determine whether or not the results from each laboratory are within acceptable limits of all other results. In this way, the quality assurance of ISTA accredited laboratories is maintained.

Test Development

The ISTA Rules are not a static publication, since seed-testing methods and hence the Rules are continuously evolving. Further modification of existing tests and the development of new ones is part of the work of the Technical Committees. In addition, ISTA may appoint a task force to focus on a new and specific testing need. For example, this was the approach to the demand for testing for genetically modified organisms, with the appointment of a GM Task Force.

The work of a Technical Committee may lead to the production of evidence that an existing test could be modified to improve its performance or extend its species range, or a new test may be developed. At this point data is submitted to the ISTA Method Validation Programme (ISTA, 2009c), during which both technical and statistical reviewers examine the validity of the data. Successful completion of method validation usually leads to a new Rules Proposal, which ISTA members must approve before it is introduced into the next edition of the ISTA Rules.

Test development is also supported and stimulated by the seed science research that goes on within ISTA, by individual members and in the Technical Committees. This research has an outlet in both the triennial ISTA Seed Symposium and the ISTA Journal of Seed Science and Technology.

Concluding Comments

Seed quality is the sum of multiple components. The most important of these are species and cultivar purity, analytical purity and germination, while other significant components of seed quality are seed vigor, seed health and moisture content. Assessments of seed quality are possible through field tests and a range of laboratory tests that have been validated by the International Seed Testing Association to ensure the reliability and uniformity of test results from different laboratories. The modification and extension of the current tests and development of new ones is continuous within the ISTA Technical Committees. The completion of such tests provides information about a seed lot that is useful to the seed producer, the seed company and the farmer, to guide decisions during seed production, marketing and storage with the ultimate aim of achieving successful and efficient crop production.

References

Akeson, W.R. and Widner, J.N. (1980). Laboratory Packed Sand Test for Measuring Vigor of Sugarbeet Seed. Crop Science, 20, 641-644.

Baskin, C.C and Baskin, J.M. (2000). Seeds: *Ecology, Biogeography, and Evolution of Dormancy and Germination*. Academic Press, London.

Bekendam, J., Kraak, H.L. and Vos, J (1987). Studies on Field Emergence and Vigor of Onion, Sugar Beet, Flax and Maize Seed. *Acta Horticulturae* 215: 83-94.

Harrington, J.H. (1960). Drying, Storage and Packing Seeds to Maintain Germination. *Seedsmans Digest*, 1, 16, 56, 57, 64, 66, 68.

ISTA (1995). *Handbook of Vigor Test Methods*. (eds J.H. Hampton and D. TeKrony). International Seed Testing Association, Bassersdorf, Switzerland.

ISTA (2003a) ISTA *Working Sheets on Tetrazolium Testing. Volume I: Agricultural, Vegetable and Horticultural Species.* (eds N. Leist, S Kramer and A. Jonitz). International Seed Testing Association, Bassersdorf, Switzerland.

ISTA (2003b) ISTA *Working Sheets on Tetrazolium Testing*. *Volume II: Tree and Shrub Species*. (eds N. Leist, S Kramer and A. Jonitz). International Seed Testing Association, Bassersdorf, Switzerland.

ISTA (2004) ISTA *Handbook on Seed Sampling, Second Edition*. (ed. M. Kruse), International Seed Testing Association, Bassersdorf, Switzerland.

ISTA (2006). ISTA *Handbook on Seedling Evaluation, Third Edition*. (ed. R. Don). International Seed Testing Association, Bassersdorf, Switzerland.

ISTA (2007). ISTA *Handbook on Moisture Determination* (eds H Nijenstein, J. Nydam, R. Don and C. McGill). International Seed Testing Association, Bassersdorf, Switzerland.

ISTA (2009a). International Rules for Seed Testing. International Seed Testing Association, Bassersdorf, Switzerland.

ISTA (2009b) *International Rules for Seed Testing. Annex to Chapter 7 Seed Health Testing. Seed Health Testing Methods.* International Seed Testing Association, Bassersdorf, Switzerland

ISTA (2009c) *Method Validation Programme. www.seedtest.org* International Seed Testing Association, Bassersdorf, Switzerland.

Lovato, A. and Balboni, N, (1997). Seed Vigor in Maize (Zea mays L.): Two-year Laboratory and Field Test Compared. *Italian Journal of Agronomy* 1: 1-6.

Matthews, S. (1980). Controlled Deterioration: A New Vigor Test for Crop Seeds. In *Seed Production*, (ed. P.D. Hebblethwaite) pp. 647-660, Butterworths, London.

Nijenstein, J.H. (1986). Effects of Some Factors influencing Cold Test Germination of Maize. *Seed Science and Technology* 14: 313-326.

Perry, D.A. (1973). Interacting Effects of Seed Vigor and the Environment. In *Seed Ecology*, (ed. W. Heydecker). Pp. 311-323, Butterworths, London, pp. 311-323.

Discussion

KATALIN ERTSEY: I have one question please: We have only a few methods for vigour tests in the ISTA Rules. What do you think Alison, what is the future possibility of general application of other vigour tests?

ALISON POWELL: Vigour tests will only be relevant where there is a problem of seed vigour within a species. Not all species will show differences in vigour for a variety of reasons. It is not relevant to apply vigour tests to all species without a problem of emergence or storage potential having been described in that species. You could also think about vigour tests being generally applied by having a single test for all species. We are not at that stage at the moment, but I think there is potential for two types of test for more general application. One is the conductivity test which is very attractive to people because it is rapid: there is potential for applying it to more species. The other is a new test that we are working on validation for at the moment and that is the rate of germination test. We hope to put in validation papers for that soon.

THE INFLUENCE OF SEED QUALITY ON CROP PRODUCTIVITY

Mrs. RITA ZECCHINELLI*

Summary

In all agricultural systems, the seed used for cultivation is considered one of the means of production. Moreover, the seed is the starting point, the first determinant of the future plant development and consequently the master key to success with its cultivation.

The expression "seed quality" is used in practice to describe the overall value of the seed for its intended purposes. It is a multiple concept resulting from the genetic characteristics of the seed and from other factors affecting its development, maturation and storability. Seed quality is a combination of different characteristics. Focusing on the effect of seed quality on crop productivity, the paper discusses the most relevant components identified in the choice of a suitable variety and in the characteristics affecting potential productivity, i.e. yield and market quality of the products derived from the cultivation. Seed storability is also mentioned, being an additional factor affecting seed quality and consequently crop productivity.

As secure seed supply systems are needed all over the world, a general overview on seed quality assurance is also provided, referring to the certification schemes established at international level, and to the need for uniform application of procedures and methods for seed sampling and testing.

Introduction

In the cultivation of plants for agricultural purposes, satisfactory results are reflected in a high yield of valuable products, resulting in economic benefits for the farmer and others involved in the agri-food chain.

Many production factors may affect the results of cultivation. Some of these factors depend on the geographical area, such as environmental conditions and soil characteristics; others on the economical framework, such as agronomic management (tillage, watering, fertilization, treatments). The farmer her/himself is a key factor, due to her/his skills, as far as she/he can take the relevant decisions and have access to suitable means of production. In the end, the market value affects the final result of the cultivation, depending both on local and global trends.

Wherever we are and whichever crop is cultivated, the quality of the seed used is the starting point and the most important factor for successful production. The seed is the first determinant of the future plant development and consequently of successful cultivation. Only the use of good quality seed will ensure that the advantages expected after the application of other means of production, such as watering or fertilization, are achieved. In addition, the use of good quality seed can prevent – or at least reduce - the use of costly inputs, such as chemical treatments aimed at controlling diseases or weeds, reducing at the same time the potential risks for the environment and human health. In a word, only the use of good quality seed will ensure satisfactory results from cultivation.

This is the reason why secure seed supply systems are needed all over the world, in order to get available seed of good quality to all the agricultural communities.

This is also the basis of different seed certification schemes established at national or international level and of the Quality Declared Seed System published by FAO in 1993 and revised in 2006 (1).

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Seed quality results from the functioning of the genome and from other factors occurring before and after the harvest (2). Seed quality is therefore a multiple concept, a combination of different characteristics and in practice it is used to describe the overall value of the seed for its intended purpose (3). Focusing on the effect of seed quality on crop productivity, the most relevant components may be identified in the choice and the availability of a suitable variety, in the characteristics affecting the amount of products derived from cultivation, in the quality of these products and in seed storage.

Seed Quality Factors Affecting Crop Productivity

To get satisfactory results from cultivation the seed needs to meet the requirements of the farmer in terms of the genetic characteristics of the variety, the potential yield and the marketable quality of the end product. Moreover, the good quality of the seed should be maintained up to the time of sowing.

Genetic Characteristics

Seed is the first critical input needed by farmers to improve and maintain their crop productivity. On this basis, seed security has been defined as the availability of the appropriate variety, at the right place and time, in sufficient quantity and quality (4). It is critical that any seed sold is the correct stated variety, for two reasons.

Firstly, the target of plant breeders is to introduce new varieties, the general purpose being to improve the cultivation and/or the yield and/or the quality of the derived products. It is interesting to remember that around 40 per cent of the total increase in agricultural production registered in the last 50 years at a global level has derived from the introduction of new varieties. Between 1929 and 1990 the yield produced by the cultivation of maize worldwide became four times greater and 75 per cent of this increased production has been derived from the introduction of new hybrid varieties (5). For the same period, Table 1 shows the increase in productivity recorded in Italy for maize and wheat. Compared to the years 1931-1935 (yield index = 100), the average yield per hectare rose in 50 years to a yield index of 416 (more than four times greater) for maize and to 201 for wheat (double) (6).

However, the potential of any new variety will not be realized or recognized if poor quality seed of that variety is released onto the market.

Table 1 Yield index (1931-35 = 100) for maize and wheat in Italy from the 1930s to the 1980s
(Table modified from Lorenzetti et al, 1994 (6))

	1931-35	*1941-45*	*1951-55*	*1961-65*	*1966-70*	*1971-75*	*1976-80*	*1981-85*
Maize	100	91	135	194	239	326	408	416
Wheat	100	87	121	143	163	183	195	201

Secondly, the farmer decides to select a variety on the basis of its agricultural characteristics, such as resistance to stress or disease, or its productivity and the recognized value of its products. He has therefore selected the variety for a specific situation and purpose, so it is essential that he has the correct variety.

Thus, the expected potential of a new variety or any well-known variety will not be expressed in actual advantages and profits if poor quality seed is used. This can be due to a deficiency in physical or physiological requirements, such as physical purity, germination, vigour, seed health, or to low genetic purity of the seed lot or even to a mis-identification of the variety.

Variety testing represents the most useful tool to evaluate the genetic quality of the seed and may be aimed at identifying the variety, to discriminate between different varieties, to check for genetic purity or to provide a characterization of the variety. The variety characterization is particularly significant for any new variety aimed at being registered in varietal catalogues in order to check its distinctness and to provide a description to be used for future needs. The possibility of evaluating a seed lot, identifying the variety to which it belongs, checking its purity, and discriminating between different varieties are crucial points for the seed trade and for seed certification schemes.

Various varietal testing methods have been developed and selected depending on the purpose of the test and on the part of the plant that is examined; seeds or seedlings (laboratory tests) or the whole plant during the course of its entire life cycle (field trials). Moreover, different approaches may be suitable for different species. Thus a wide range of solutions is available (7).

The list includes traditional methods based on the observation of morphological characteristics or on chemical reactions, biochemical methods (analysis of seed proteins or isozymes by electrophoresis) and the more recent DNA-based methods.

Crop Yield

The correlation between the quality of the seed used for cultivation and the yield obtained from this cultivation is universally recognized. Depending on the type of crop, the relationship between seed quality and crop yield is different and differently relevant. In general, germination capability and seed vigour represent the master keys to achieve the rapid germination and good emergence needed to ensure an appropriate plant population. Close- spaced crops that can tiller can compensate, to a certain extent, for the reduced emergence that results from lowered germination capability or seed vigour. Thus, tillering in cereals such as wheat, barley and rice can maintain a constant yield (production of seeds or grains per unit area) over a range in plant population (8). Of course, a very poor level of germination or very low seed vigour will affect the yield even in these crops, even more significantly if associated with other undesirable features (e.g. presence of weed seeds or seed-transmitted pathogens).

Germination and seed vigour are however more important for wide-spaced crops (e.g. maize, sugar beet, cotton, sunflower). Fig. 1 gives the different field emergence shown by samples belonging to different seed lots – all sown at the same time - when sowing is done in poor conditions (cold and wet weather).

Fig. 1 Maize Plot Trial (Italy, 2009): Field Emergence of Seed Lots with Different Seed Vigour

Germination and seed vigour are also highly significant for crops harvested during vegetative growth or before full reproductive maturity, such as many vegetable species. In these cases there is no compensatory growth, so a small reduction in the plant population can be the reason for a reduced yield (9).

Table 2 shows how emergence and seedling growth in Brassica species is affected by seed vigour. All samples in the laboratory showed high germination rates, while after controlled deterioration, the samples showed differences in seed vigour.

The lower seed vigour (lower CD germination) explains the higher emergence time (MET), the lower final emergence rate and the reduced seedling growth observed in the transplant modules (10).

Table 2 Effect of Brassica seed quality (CD germination = seed vigour determined by a germination test after controlled deterioration) on mean emergence time (MET), final emergence and seedling growth in transplant modules
(Table modified from Powell et al, 1991 (10))

Species	*Sample*	*Laboratory germination (%)*	*CD) germination (%)*	*MET (days)*	*Final emergence (%)*	*Plant height at 1st leaf stage (mm)*	*Coefficient of variation of plant height*
Cauliflower	1	98	99	4.4 (4)	92	26.7	21.5
	2	90	37	6.2 (14)	88	19.8	25.9
Brussels	1	98	100	4.2 (3)	100	30.8	23.9
sprouts	2	100	57	4.7(3)	50	27.2	19.7
Dutch	1	98	95	4.4 (4)	98	21.8	27.0
cabbage	2	93	66	5.3 (6)	92	18.2	36.9
Red	1	97	97	4.6 (5)	98	25.6	22.1
cabbage	2	85	32	5.7 (7)	100	16.8	32.5
Calabrese	1	99	100	4.1 (9)	96	21.0	14.7
	2	93	54	4.1 (13)	92	21.0	20.5

Crop yield and productivity are also influenced by seed hygiene, that is, seed health, weed and insect contamination and high quality standards always have a positive effect. On the contrary, a noxious weed infestation or the occurrence of plant diseases can reduce the yield in all crops, directly, or as a result of competition for physical resources or exploitation of plant resources.

Of course, some circumstances make the presence of noxious weed or of pathogens a more serious issue. This is the case of organic farming, where the agricultural practice limits the use of chemical treatments and the possible risk of contamination with weeds and pathogens transmitted by the seed become greater than in conventional systems (11).

This is also the case in some areas where the availability or the costs of herbicides and other chemicals represent a challenge.

Here it is worth mentioning that for some seed-borne pathogens (e.g. bacteria) no effective chemical methods are available and the most suitable way to prevent disease is the use of healthy seed.

In order to ensure high yields worldwide and to maintain high productive standards, seed testing again plays a very important role. Evaluation of seed quality by purity and germination tests have been common practice since the beginning of the history of seed testing, when Prof. Nobbe founded in Germany the first seed testing station in 1869. Purity and germination still represent the most popular kinds of test many seed testing laboratories are asked to carry out with the aim of ensuring high germination and freedom from undesirable weed seeds. The physical purity test is carried out with the aim of evaluating the percentage of pure seed, of seeds belonging to other species and of inert matter. The identification of the other seeds retrieved is also required. The object of the germination test is the evaluation of the maximum germination potential of the pure seed. The seed is therefore germinated in optimal conditions to allow the maximum expression of its potentiality. To evaluate the planting value of a seed lot in a wide range of environments, providing additional information to the standard germination test, a range of vigour tests is available (12). Worldwide high purity and germination standards are important, while the additional evaluation of seed vigour is often required in more developed agricultural systems.

Many seed certification schemes provide minimum germination and purity standards. These schemes often also include requirements concerning particular species that are considered to be very dangerous, whose presence in the analyzed sample is limited or even banned. Examples are some parasitic plants, such as Cuscuta spp (Fig. 2) and Orobanche spp.

Seed health testing laboratories are asked to carry out a range of analyses as seeds may be contaminated or infested by different types of pathogens, fungi, bacteria, viruses and nematodes. These tests may be addressed to check quarantine requirements established by phytosanitary regulations with the aim of avoiding the entry of dangerous pathogens in non-infected areas or in general to prevent the spread of economically important pests. Seed heath testing is also required by some certification schemes or carried out routinely for monitoring purposes.

Fig. 2 Cuscuta spp in a Seed Sample and in a Field of Trifolium resupinatum (Persian Clover)

Quality of the Products derived from Cultivation

The marketable quality recognized in the product obtained from a cultivation contributes to its final economical output. Firstly, this value is once again a consequence of intrinsic features, i.e. the genetic characteristics of the species and the variety. As an example, Triticum species and varieties are characterized by a different grain composition, in particular of the storage proteins, that make the different species and the different varieties suitable for the production of pasta, bread, biscuits or other milled products. Mixtures of species or varieties may reduce the market quality and the quotation recognized to the farmer (Fig. 3).

Fig. 3 Triticum aestivum in a Field and in a Seed Sample of Triticum durum

Other factors are also important: the occurrence of a seed-borne disease may reduce not only the yield, but also the marketable value of the products showing symptoms of the disease, particularly in horticultural crops.

Low germination as low vigour affects plant density in the field or in the greenhouse and this may cause differences in the growth of the plants. In root vegetables (e.g. carrot, horticultural swede), this situation is translated into varied root size and hence in a reduction of its market value.

Low germination and seed vigour do not allow for the uniform emergence that is necessary in the production of young plants to be transplanted (tomato, pepper, eggplant, cabbage, tobacco, forest species) or in the case of vegetable crops aimed to be harvested at regular and planned times, for example for freezing (peas), or when plants uniform in size and stage of development are required (green vegetables, i.e. lettuce).

Seed Storage

Seed quality is also affected by factors occurring during post-harvest stages. The storage life of seeds depends on storage conditions (temperature, relative humidity), on the initial quality of the seed and on its moisture content.

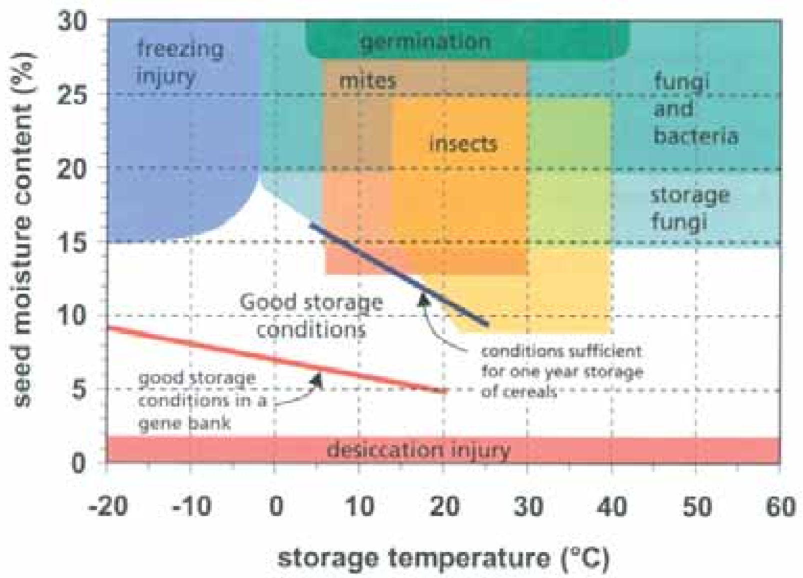
Moisture content may affect seed storability in a different way, depending on the species. Categories of seeds have been proposed to group the species in relation to their post-harvest behaviour, i.e. orthodox, intermediate or recalcitrant. A detailed discussion on this classification, as on other subjects related to the moisture content in seeds, can be found in the ISTA Handbook on Moisture Determination (13). In general, low moisture content promotes the storability of orthodox seeds, while the viability and storability of recalcitrant seeds is affected in a negative way by low moisture content.

Under uncontrolled storage conditions, seed moisture content may show wide variations, depending on ambient conditions. In tropical countries with high humidity and temperatures, orthodox seeds stored in poor conditions lose their ability to germinate: the lower is the initial seed quality, the quicker is the loss of viability.

Seed moisture content also affects the activity of pathogens and in particular of insects and mites, causing additional damages.

Fig. 4 is taken from the ISTA Handbook on Moisture Determination (13). It shows the effects of the combination of seed moisture content and storage temperature on the storability of seeds and the risk of injuries and infestations which can occur in the different conditions.

Fig. 4 Biological Activity in and around Seeds during Storage (13)



For all these reasons, seed moisture content has always been one of the parameters taken into account to determine the market value of seed, and its determination by suitable testing methods is therefore very important. Following the definition provided by the ISTA Rules (10), the moisture content of a sample is the loss in weight when it is dried. It is expressed as a percentage of the weight of the original sample.

Certification as a Means to achieve Good Seed Quality

The relevance of seed quality is recognized by all the seed certification schemes. Moreover, the need for good quality seed is itself the basis of these schemes.

The EU established a seed certification system, starting in the 1960s (the EU Seed Directives may be downloaded from *http://eur-lex.europa.eu*; useful lists and links are also available on the European Seed Association website: *http://www.euroseeds.org/static/worldwide-links*).

EU Seed Directives regulate the marketing of seed of different groups of species (cereals, fodder plants, oil and fibre plants, beet species, vegetable species, seed potatoes). They are based on the assumption that satisfactory results in cultivation depend to a large extent on the use of appropriate seed. The EU certification schemes take into account the characteristics of the variety. Moreover, the EU Seed Directives take into consideration other kinds of requirement such as the requirements checked by lab testing (for the majority of crops, germination, purity, other seed determination).

The objective of the OECD Schemes for the Varietal Certification (six schemes for six groups of agricultural species) or the Control (a scheme for vegetables) of Seed Moving in International Trade is to encourage the use of seed of consistently high quality in participating countries.

The assessment of seed quality, and particularly of its genetic/varietal characteristics, is based on agreed principles and rules. Fifty-seven countries from all geographical areas are participating in the OECD seed schemes (http://www.oecd.org/document/0/0,3343,en_2649_33905_1933504_1_1_1_37401,00.html). Both in the case of the EU and OECD schemes, the evidence of certification is given by labels and certificates.

The importance of seed quality assurance is also the basis for ISTA's work and activities in addressing the different aspects of seed quality evaluation.

The ISTA vision is "Uniform in Seed Testing" world wide and its mission describes how to achieve this vision. ISTA's primary purpose is to develop, adopt and publish standard procedures for sampling and testing seeds, and to promote uniform application of these procedures for the evaluation of seeds involved in international trade. The ISTA Rules include standardized methods for seed sampling and testing (e.g. germination conditions and methods are provided for over 1000 species), together with other useful information, such as definitions and instructions for reporting testing results.

FAO recognizes that seed quality assurance is a key factor for establishing food security, particularly in developing countries. Nevertheless in many countries seed and propagating material available to farmers are often of insufficient quality.

For these reasons, FAO decided to support countries in raising the quality of seed produced locally and used by small-scale farmers. In 1993, FAO presented the Quality Declared Seed System, later revised in 2006 (1). The system includes guidelines to be applied in the production of quality seed. It provides an alternative for seed quality assurance, particularly designed for countries with limited resources and it is less demanding than full seed quality control systems but yet guarantees a satisfactory level of seed quality.

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References

1) FAO, 2006. Quality Declared Seed System. FAO Plant Production and Protection Paper 185 - *www.fao.org/docrep/009/a0503e/a0503e00.htm*.

2) Powell et al., 2005. Towards the Future in Seed Production, Evaluation and Improvement, *Seed Science and Technology* 33, 265-281.

3) Hampton, 2002. What is Seed Quality? Seed Science and Technology 30, 1-10.

4) Mekbib, 2008. Farmers' Seed System of Sorghum [Sorghum bicolor (L.) Moench] in the Center of Diversity: II. Seed Quality, Storage, Protection and Security. *Journal of New Seeds* 9, 3, 191-211.

5) Chrispeels and Sadava, 2003. *Plants, Genes, and Crop Biotechnology*. Published by Jones and Bartlett Publishers. 619 pp (Edizione Italiana, 2005 coordinata da F. Sala).

6) Lorenzetti, Falcinelli, Veronesi, 1994. *Miglioramento genetico delle piante agrarie*. Published by Edagricole. 328 pp.

7) Skerritt and Appels, 1995. *New Diagnostics in Crop Science. Biotechnology in Agriculture* 13. Published by CAB International. 338 pp.

8) Puckridge and Donald, 1967. Competition among Wheat Plants sown at a Wide Range of Densities, Australian *Journal of Agricultural Research*, 18 (2), 193-211.

9) TeKrony and Egli, 1991. Relationship of Seed Vigor to Crop Yield: A Review. Crop Science 31, 816-822.

10) Powell, Thornton, Mitchell, 1991. Vigour Differences in Brassica Seed and their Significance to Emergence and Seedling Variability. *Journal of Agricultural Science*, Cambridge, 116, 369-373.

11) Steven at al., 2004. Challenges for the Production of High-Quality Organic Seeds. *Seed Testing International* 127, 12-15.

12) *International Rules for Seed Testing*, 2009. Published by ISTA.

13) ISTA Handbook on Moisture Determination. 2007. Edited by the ISTA Moisture Committee (Nijenstein et al.). Published by ISTA. 248 pp.

Discussion

PETER LATUS: PETER LATUS FROM THE SWISS FEDERAL OFFICE FOR AGRICULTURE. The first two speakers did not point out the necessity of very good seed sampling, and I would like to point out that the work you do in the laboratory only can be as good as the sample representing the seed lot. So that is what I wanted to say. Thank you.

KATALIN ERTSEY: Thank you for this remark, because it is a very important topic. I underlined also but time is short.

BERT VISSER: My name is Bert Visser from Wageningen University. I have a technical question and this relates to the role of seed moisture to vigour and plant emergence. Is it your view or your opinion or experience that there is a linear relationship in the sense that when seed moisture decreases, seed quality improves and vigour improves and plant emergence improves, or is there an optimum in seed moisture contents? What is your view on that?

KATALIN ERTSEY: I think this question is for two speakers and I think it is a very important question as well and there are also some differences between the really scientific results and also the minimum requirements in the laws; therefore I think we can postpone this question to the general discussion. Thank you. OK?

JACQUES GENNATAS: Thank you Madam. Gennatas from the European Commission. As we got the second talk by Ms. Zecchinelli, I have a short question. You mention the criteria to accredit laboratories. On which base do you accredit laboratories; governmental and non-governmental laboratories? Do you have ISO standard or what are the standards for accreditation? Thank you very much.

RITA ZECCHINELLI: I have to say that I did not mention accreditation in my talk, but nevertheless. I do not understand if your question referred to ISTA accreditation or to the authorisation… No, to ISTA accreditation.

KATALIN ERTSEY: Please, I would like to postpone also this question because the next presentation covers this item and I hope you will get your answer. OK? Thank you.

THE EVOLUTION OF SEED TESTING

Mr. MICHAEL MUSCHICK*

Introduction

With the change from hunting and gathering to agricultural and animal production in the Neolithic revolution, seeds, or to be more precise, healthy seeds, have become one of the most important products for the survival of human beings. The knowledge that seeds are the part of the plant that have the potential to produce new, healthy plants is the key to food production, food security and ultimately survival of the population. It was obvious, very early on that environmental conditions have a major influence on the successful realization of the potential of a seed to produce a healthy plant and in all religions you find examples of praying to God, or the gods, for favorable environmental conditions. However, it took until the beginning of the 19th century before researchers and botanists started to intensively study the morphological characteristics of seed and start investigating their physiology and that of the germination process.

The Origins of Seed Testing

By the 19th century the sale and trade of seed existed in Europe. Merchants were traveling over long distances from market to market to sell seed and local farmers offered seed for sale or barter to their neighbors and at local markets. Nothing was known about the purity of the seed that was traded nor even its potential to produce a crop (Nobbe, 1876).

It was in April 1869, when a Saxon agronomist, the Count of Lippe-Weissenfeld, submitted several grass seed samples, bought on the local market, for botanical recognition to Prof. Dr. Nobbe, a botanist working at the Royal Academy for Foresters and Agronomists at Tharandt, Saxony, Germany (Nobbe, 1876). Surprisingly, one sample tagged "Tall Fescue" turned out to contain only 30% true seeds and other seed samples that were sent to the Academy for growing trials had similar shortcomings and other deficiencies.

Prof. Dr. Nobbe initiated further investigations on the quality of traded seed and found that the situation was far from acceptable. He quickly realized that in addition to the limited knowledge of traders and farmers regarding seed species identification, there was also a lot of cheating, swindling and fraud in the seed market. Consequently, this resulted in his publication in May 1869 entitled: *On the Necessity for Control of the Agricultural Seed Market.*

In terms of seed quality Prof. Dr. Nobbe considered what to measure, how to measure and when to measure. Addressing these questions he proposed that measurements should be made of the trueness to species, the purity of seeds and the potential the seed has to produce healthy seedlings. He also came up with the revolutionary idea that these measures of quality should be assessed before the seed was sold to farmers so they could be sure that the seed they bought had the potential to give them a good harvest. This inspiration would not only tackle the cheating, swindling and fraud that existed in the seed market, but would also give farmers an assurance that they had the necessary starting material for a successful harvest, provided the environmental factors were reasonably favorable and the farmer used the necessary cultivation and husbandry skills. Implementing Prof. Dr. Nobbe's ideas was the key to an increase in overall plant production.

From a technical point of view many questions arose:

- How do you obtain a representative sample from a lot that is to be sold?
- How can one ensure that seed quality results represent the quality of the lot that has been tested?

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- How do you differentiate between the seeds of different species?
- How do you measure the germination potential of different species?

Answers required an understanding of populations and a detailed knowledge of the morphology of seeds and plant and seed physiology. Prof. Dr. Nobbe immediately rose to the challenge and worked out methodologies for sampling and testing (Nobbe, 1876). This was the starting point for seed testing which consists, in effect, of measurements made to determine the potential and value of seed before it is planted in the field.

International Spread of the Idea and International Collaboration 1869 - 1924

Nobbe's revolutionary ideas spread rapidly around the world. Already, in 1875, 12 seed-testing stations had been established in Germany, Austria-Hungary, Belgium, Denmark and the United States and in the period 1876/77 more than 20 new seed-testing laboratories were founded. In 1896, a good quarter of a century after Nobbe's initiation, there were a total of 119 seed-testing stations in 19 different countries (Steiner and Kruse, 2006).

All of these stations were actively gathering information on the seed market and working on the identification of different species of seed and the development of sampling, purity, germination and moisture methodologies for an increasing group of species. Seed health observations were also being made. It is obvious that this work involved the application of scientific principles and a deep knowledge of plant morphology and physiology was required. This accounts for the fact that nearly all of the heads of these seed-testing laboratories came from academia and had been botanists.

In 1875 a first meeting of directors of seed-testing stations took place in Graz where experiences were shared on the development of the methodologies. It was recommended that the methods in the Handbook of Seed Testing by Nobbe, which would be published in 1876, should be standard use in seed-testing laboratories. A follow-up meeting took place in Hamburg in 1876 and the motto "Uniformity in Seed Testing" was coined and discussions were initiated on how to achieve it (Steiner and Kruse, 2006). Even today this topic continues to be on the agenda.

In 1906 a first Conference for Seed Testing was held in Hamburg, Germany and this can be viewed as the starting point for seed-testing conferences. The second seed-testing conference was held in Münster/Wageningen, Germany/Netherlands in 1910; the third conference took place 1921 in Copenhagen, Denmark and the fourth in 1924 in Cambridge, UK.

Since the first conference in 1906 there has been a desire to work towards standards for seed testing; internationally approved methods; the uniform application of these methods. To help achieve this, the European Seed Testing Association was founded at the 1921 meeting in Copenhagen (MAF, 1925).

1924 – The Founding of the International Seed Testing Association

At the conference in 1924 in Cambridge it was decided to enlarge the scope of the European Seed Testing Association and to extend its activities to all the countries of the world in which the testing of seeds was practiced. It was also decided to re-constitute it under the name of the International Seed Testing Association (MAF, 1925).

Paragraph 1 of the 1924 ISTA Constitution stated:

"Under the name of the International Seed Testing Association, a union of Official Seed Testing Stations with legal domicile at the residence of its President exists for the purpose of advancing all questions connected with the testing and judgment of seeds. The Association seeks to attain this object through:

(a) Comparative tests and other research directed to achieving more accurate and uniform results than hitherto obtained.

(b) The formulation of uniform methods and uniform terms in the analysis of seeds in international trade.
(c) The organization of international congresses attended by representatives of Official Seed Testing Stations for the purpose of mutual deliberation and information, the publication of treaties and reports on seed testing and mutual assistance in the training of technical officers".

The first President was Mr. K Dorph Petersen from Denmark and the Vice President was Dr. Franck from the Netherlands. In addition to the office holders there were three Executive Committee members: Prof. M.T. Munn, US, (who was also President of the AOSA), Mr. W.V. Petery, Argentina and Mr. A. Eastham, UK.

Nine Committees were established:
1. Research Committee for Countries with a Temperate Climate
2. Research Committee for Countries with a Warm Climate
3. Provenance Determinations
4. Hard Seeds and Broken Seedlings
5. Moisture Content and Drying
6. Investigations of Genuineness of Variety and of Plant Diseases
7. Dodder Committee
8. Publications and Registration
9. Beet Sub-Committee

1931 – The Establishment of the International Rules for Seed Testing 1931

The Chairman of the Research Committee for Countries with a Temperate Climate, Dr. W.J. Franck, Wageningen, Netherlands, presented the first draft of international rules for seed testing at the 5th Seed Testing Conference in Rome (ISTA, 1931). The draft was not, however, approved due to certain disagreements on purity tolerance as well as on the evaluation of germination capacity.

At the 6th International Congress of Seed Testing held in Wageningen, Netherlands on July 17,, 1931 a revised version of the International Rules for Seed Testing was put to the vote and approved (ISTA, 1931).

These rules describe:
- Sampling
- Purity testing
- Germination
- Additional determinations
    - Sanitary condition
    - Genuineness of variety
    - Provenance
    - Weight determinations
    - Determination of the moisture content
- Evaluation and reports
- Tolerances
- Hard seeds
- International certificates

Since the establishment of the ISTA International Rules for Seed Testing, discussions have continued in all these different areas of seed testing and new test concepts have also been added to the Rules. Existing chapters have continuously been revised, modified and enhanced to increase uniformity, efficiency and effectiveness.

The historical papers of ISTA and ISTA's journal publications (Proceedings of the International Seed Testing Association which was renamed Seed Science and Technology in 1973) give a detailed insight into the different discussions, developments and important milestones in the area of germination, seed health and purity testing (see Jensen, 2008; Klitgard, 2002; Mathur and Jorgensen, 2002). Today, the ISTA Rules are set out in 16 different chapters and sum up the findings of 140 years of worldwide research and the discussions at 28 seed-testing congresses.

1931 – The Establishment of ISTA International Certificates

With the establishment of the international rules for seed testing and a uniform reporting system, a certificate that facilitated the international trade of seed was established. The 1931 Ordinary Meeting of the Association adopted two different certificates, the Orange International Seed Certificate and the Blue International Seed Certificate. The Orange Certificate gives results representing the average quality of the seed lot which has been sampled according to ISTA Rules. The Blue Certificate gives results that relate to quality of the sample submitted for testing (ISTA, 1931).

1950 – The 9th International Seed Testing Congress in Washington, US

The 8th International Seed Testing Congress took place in 1937 in Zurich, Switzerland. At this Congress, an invitation from the Association of Official Seed Analysts of North America to hold the next congress in North America was submitted and accepted. Unfortunately, however, the war intervened and the Congress had to be postponed. After the end of the war international connections were gradually re-established with the resumption of correspondence between the Executive Committee and other members of the International Seed Testing Association. The need for working towards "Uniformity in Seed Testing" was still obvious and the 9th International Seed Testing Congress was held from May 8 -13, 1950 in Washington, D.C., US. During this Congress, alterations to the existing International Rules for Seed Testing were tabled and a new Constitution of the International Seed Testing Association was proposed, discussed and voted on (ISTA, 1951).

1966 – Introduction of Seed Health Methods in the International Rules for Seed Testing

Already in 1907, Appel had drawn attention to the fact that information on the occurrence of seed-borne pathogens could be obtained during seed testing in the laboratory. In 1919 the Seed Testing Station at Wageningen established a special division for studying the sanitary conditions of seeds. With the foundation of the International Seed Testing Association in 1924 the Committee for Investigation of Genuineness of Variety and of Plant Diseases was founded and in 1928 a separate committee, the Plant Disease Committee (PDC), was founded. In 1928, the Chairman of the PDC suggested to the 5th ISTA Congress that information on the occurrence of certain fungi on seed samples should be reported on ISTA certificates (Mathur and Jorgensen, 2002). The Congress agreed that such information could be of advantage, but also realized that not many seed-testing stations had sufficient experience and before such information could be put on the certificate, a number of comparative examinations should be undertaken to ensure that the results reported by the various stations agreed within reasonable margins.

The aim of the comparative testing program was the establishment of internationally standardized seed health testing procedures. With selecting methods to be included in the ISTA Rules, the results of comparative seed health tests had to be evaluated carefully in order to select methods that gave rise to uniformity of results between laboratories carrying them out. In 1966 the first specific seed health testing methods were included in the ISTA Rules (Mathur and Jorgensen, 2002). Today, the ISTA has standardized 21 seed health testing methods, which are included in the ISTA Rules and can also be downloaded free-of-charge from the ISTA website.

1966 – Introduction of the Topographical Tetrazolium Test in the International Rules for Seed Testing

The topographical tetrazolium test is a biochemical test that may be used to make a rapid assessment of seed viability: when seeds have to be sown shortly after harvest; in seeds with deep dormancy; in seeds showing slow germination or in cases where a very quick estimate of germination potential is required. Biochemical viability tests were introduced to seed testing by Hasegawa and a report was given at the 1937 ISTA congress in Zurich introducing the Eidamnn-Hasagawa method. In 1939, Lakon, at Hohenheim, Germany, started working in this field and made a presentation at the 1950 ISTA Congress with the title: "Further Research regarding the Topographical Tetrazolium Test and the

Determination of the Viability". In 1956, the ISTA Tetrazolium Committee was set up and in 1966 the Tetrazolium test was introduced as a standardized test into the International Rules for Seed Testing (Steiner, 1997).

1995 – The Establishment of an International Accreditation Standard for Seed Testing Laboratories by ISTA

The achievement of accurate results and the uniformity of seed testing results, or to update the language, the reproducibility of results, has been an important point of discussion and consideration since seed testing was started by Prof. Dr. Nobbe in 1869.

Prof. Dr. Nobbe initiated comparative tests in 1877 and method validation has been a part of ISTA's activities since the beginning of seed testing. With the introduction of quality management systems, particularly those for analytical laboratories in the 1970s, quality management became a topic for discussion in seed-testing stations and at seed-testing congresses. The establishment by the OECD of the Guidelines for Good Laboratory Practice (GLP) was a starting point for this development. The aims of the GLP can be described as: the traceability of analysis through documentation; the definition of responsibilities and clear, precise descriptions of the organization; and the production of accurate and reproducible results of products.

The overall development and discussion resulted in the generic standard ISO 17025 for the accreditation of all types of analytical laboratories. Nevertheless, at an early stage seed scientists realized that for seed-testing laboratories special conditions were required and many of the requirements of ISO 17025 had already been realized in seed-testing stations.

An ISTA working group operating in the period 1992-1995 developed the ISTA Accreditation Standard for seed-testing laboratories. This standard was approved at the Ordinary Meeting in 1995. The already existing "referee tests", as they were called at that time, were modified, extended and adopted to become international proficiency tests and an internationally operating accreditation body was founded at the ISTA Secretariat. This body was tasked with carrying out the required three-yearly quality assurance assessments of laboratories that applied to be ISTA-accredited. In addition, the 1995 Ordinary Meeting of ISTA decided that only ISTA-accredited laboratories could issue ISTA certificates from r 2001 onwards (ISTA, 1993; ISTA, 1998).

2001 – Introduction of the Vigour Methods into the International Rules for Seed Testing

Seed vigour is the sum of those properties that determine the activity and performance of seed lots of acceptable germination in a wide range of environments, and the objective of a seed vigour test is to provide information about the planting value of seed lots in a wide range of environments and/or their storage potential. Discussion regarding the inclusion of vigour methods in the ISTA rules started during the 26th ISTA Congress in 1998 in Johannesburg, South Africa; however, critical voices were raised and the proposal was withdrawn, revised and forwarded to the 27th ISTA Congress in 2001 at Angers, France. At this Congress, ISTA member governments voted for the inclusion of two vigour methods into the ISTA International Rules for Seed Testing - the conductivity test for Pisum sativum and the accelerated aging test for Glycine max. At the 2009 Ordinary Meeting of ISTA in Zurich, the conductivity method was extended to include Phaseolus beans and the controlled deterioration vigour test method was added for Brassica species (ISTA, 2001).

2004 – The Introduction of Performance-Based Methods for GM Testing

With the introduction of genetically modified varieties and their commercial release in some countries, seed-testing laboratories were being faced with new challenges. Questions on purity of GM seed lots as well as the adventitious presence of GM seed in non-GM seed lots were at the center of the discussions. Since 2000, the ISTA GMO Task Force has discussed intensively these questions. For ISTA, the fundamental question was whether it would be possible to achieve international harmonization of the testing methodologies. It was concluded that method development in this particular area is so vibrant that the standardization of testing methodology is nearly impossible since by the time agreement for a certain methodology had been achieved the methodology would most likely already be outdated. Furthermore, it was realized that the implementation of a standardized methodology in a laboratory could in this instance create major obstacles and produce a negative effect resulting in less accurate results. For these reasons the concept of performance-based methods was discussed, proposed and accepted for methodologies in this particular area of testing. Under this approach a laboratory is entitled to use any method it considers adequate on condition that the laboratory provides sufficient performance data for the methodology according to clearly defined requirements. This approach received the backing of ISTA member governments and, today, Chapter 8 of the ISTA International Rules for Seed Testing specifies this kind of test principle for bio-molecular tests and bioassays used in testing for the presence of specified traits (ISTA, 2004).

2004 – Opening-up of ISTA's Quality Assurance Program to Private Sector Laboratories including the Issuance of ISTA Certificates

At the 28th ISTA Congress in 2004 in Budapest, Hungary, a proposal was accepted that permitted private sector laboratories to issue ISTA certificates under the same conditions that applied to public sector laboratories, i.e. they must participate in the ISTA Quality Assurance Program, successfully participate in ISTA proficiency tests and achieve ISTA accreditation. Therefore, the focus, for issuing certificates now depends on the individual performance of a laboratory rather than on its status. Strict monitoring guarantees the performance of the labs (ISTA, 2004).

Recent Developments

Since the beginning of the 1990s it has become evident that there has been a reduction in investment in nearly all areas of seed technology at university level and within public seed-testing stations (Jensen, 2008). Since then, important international training programs at university level have ceased (e.g. the training programs in Edinburgh and Mississippi State Universities). This development needs to be seen as a threat to seed work in the public as well as the private sectors. Today, there are almost no universities offering specialized training in seed science and technology. The consequences of this development are unavoidable.

The reduction of capacities in the public sector and in large public seed-testing stations reduces activities in applied seed science. The reduction of resources means that stations' activities are limited to the performance of simple routine control and monitoring tasks and this reduces their ability to provide on-the-job training for seed analysts from developing countries. Furthermore, with the increasing activity of applied seed science in the private sector being used to competitive advantage in business, research results are not published and uniformity in seed testing is threatened. This, without any doubt, could have negative implications for the international seed trade. It is recommended that governments, the public and private sectors carefully consider these developments, draw the right conclusions from them and take appropriate action to address them.

Conclusions

Seed testing, as a concept to determine the value of seed before it is planted in the farmer's field, has spread rapidly throughout the world since its inception in 1869 and is used universally to provide information on the planting value of seed to the farmer and the legislator. An in-depth knowledge of plant and seed morphology, taxonomy and physiology were prerequisites for the development of seed-testing methodologies and leading players in the method development field have been scientists dealing with the wishes and needs of the seed trade and seed markets. Likewise, research and development activity in different areas of seed science and technology also increased rapidly throughout the world and today's International Rules for Seed Testing are the result of the combined knowledge of 140 years of applied seed science and the essence of the discussions at 28 international seed congresses.

Quality management systems have been successfully introduced and put into practice at the global level. An evaluation of the results of this (e.g. proficiency tests, performance of accredited laboratories compared to non-accredited laboratories) demonstrate that this has been a success in optimizing the performance of laboratories and minimizing the risk of inaccurate testing.

From the founding of ISTA until around 1990, most ISTA seed laboratories received substantial financial support for both the running of their laboratories and for support for international activities in ISTA and similar organizations. Due to decreasing government support and privatization of seed-testing services, the voluntary work within the technical committees of ISTA as well as the transparent sharing of recent research results has become more and more limited. This lack of clarity of responsibility between the public and private sectors and the reduction of resources, as well as the use of recent research work as competitive advantage for single companies, is seen as a threat and the major challenge for successful continuation of the evolution in seed testing: policymakers, the seed industry and farmers should keep this in mind.

It is obvious, that the evolution of seed-testing methodologies has not reached a conclusion:

- Continuous improvements and research are necessary and are required to enhance efficiency and effectiveness of seed testing and provide the tests needed to meet the changing needs of the market.
- Quality assurance management needs to be further developed to minimize the risks and give customers confidence.
- DNA technology will result in progress, new needs and challenges for seed testing.

The evolution of seed testing needs to continue.

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References

Anonymous (1925). Report of the Fourth International Seed Testing Congress. His Majesty's Stationery Office, London.

Anonymous (1931). Report of the Sixth International Seed Testing Congress. *Proceedings of the International Seed Testing Association*, 3, 5-394.

Anonymous (1935). Report of the Seventh International Seed Testing Congress. *Proceedings of the International Seed Testing Association*, 6,140-519.

Anonymous (1938). Report of the Eighth International Seed Testing Congress. *Proceedings of the International Seed Testing Association*, 10, 9-502.

Anonymous (1951). Report of the Ninth International Seed Testing Congress. *Proceedings of the International Seed Testing Association*, 16,109-541.

Anonymous (1993). Twenty-Third International Seed Testing Congress 1992. *Seed Science and Technology*, 21, Supplement 1, 1-262.

Anonymous (1996). Twenty-Fourth International Seed Testing Congress 1995. *Seed Science and Technology*, 24, Supplement 2, 1-249.

Anonymous (2001). Twenty-Sixth International Seed Testing Congress 2001. *Seed Science and Technology*, 29, Supplement 3, 1-112.

Anonymous (2004). Minutes of the ISTA Ordinary Meeting 2004. International Seed Testing Association Archive, Bassersdorf, Switzerland.

Doyer, L.C. (1930). *Untersuchungen über den Gesundheitszustand des Saatguts. Proceedings of the International Seed Testing Association*, 13, 1-41.

Jahnel, H. and Ludwig, H. (1961). Friedrich Nobbe, *der Begründer der Samenkontrolle. Proceedings of the International Seed Testing Association,* 26, 127-139.

Jensen, H.A. (2008). Development of ISTA Purity Analysis and Determination of Other Seeds by Number from 1924 to 2006. *ISTA Historical Papers*, 2, 3-37.

Klitgård, K. (2002). ISTA 1924-1999 Progress Report on the Testing of Germination. ISTA *Historical Papers*, 1, 35-58.

Mathur, S.B. and Jorgensen, J. (2002). A Review of the Activities of the Plant Disease Committee of ISTA through its 75 Years of Existence, 1924-1999. *ISTA Historical papers*, 1, 1-34.

Maude, R.B. (1996). Seed-Borne Diseases and their Control. CAB International, Wallingford, UK.

Nobbe, F (1869). *Über die Notwendigkeit einer Kontrolle des landwirtschaftlichen Samenmarktes, Ldw. Vers.-Stat*., 11, 308-311.

Nobbe, F. (1876). *Handbuch der Samenkunde. Wiegandt*, Hempel & Parey, Berlin.

Steiner, A.M. (1997). History of the Development of Biochemical Viability *Determination in Seeds. Proceedings of the ISTA Tetrazolium Workshop*, 7-16.

Steiner, A.M. and Kruse, M (2006). Centennial - The 1st International Conference for Seed Testing 1906 in Hamburg, Germany. *Seed Testing International*, 132, 19-21.

Steiner, A.M. and Kruse, M. (2007). Nobbe's Statute concerning the Testing of Agricultural Seeds of August 1869. *Seed Testing International*, 134, 11-13.

Steiner, A.M., Kruse, M. and Leist, N. (2008). ISTA Method Validation 2007: A Historical Retrospect. *Seed Testing International*, 136, 30-33.

Wellington, P.S. and Silvey, V. (1997). *Crop and Seed Improvement - A History of the National Institute of Agricultural Botany* 1919 to 1996. The Dorset Press, Dorchester, UK.

Discussion

ORLANDO DE PONTI: My name is Orlando de Ponti, President of the International Seed Federation. Mr. Muschick I think it is very important that you mentioned in your final slide that we are facing the situation that in the public arena, universities, institutes, there is a decreasing attention/investment in the development of new testing procedures based on latest developments in scientific fields. Yesterday during various sessions we have emphasised the importance of public-private collaboration, and I would like to mention that it is urgent, and I know you are very much aware of it, that within ISF we have what we call the International Seed Health Initiative where scientists, mainly pathologists, from companies are working together - and I would really mention this very clearly - in a non-competitive way, to develop more efficient, more cost effective seed testing procedures. They do this in their own circles and in very close collaboration with ISTA, and, as you know very well, many of those new tests have been adopted by ISTA. And I think it is very important for the audience here that they know that this is an excellent example of public-private collaboration. Thank you.

SAM KUGBEI: Sam Kugbei from FAO. The developments in the last 10 years you indicate, especially in the area of training, that it has gone down very badly. But that has coincided with the rapid development of the private sector in the seed industry. Do you think there is any role the private sector can play in correcting these defects in training?

MICHAEL MUSCHICK: Thank you for this question. It is a very good question. I can imagine that the private sector is playing a role in that, but let me stress very clearly today that we are lacking training and urgent actions are really required. So I am very open and I see a lot of possibilities in the pubic sector as well as in the private sector to address this gap. But in my opinion the gap needs to be addressed now.

GRETCHEN RECTOR: I am Gretchen Rector from Syngenta and my question is both historically and today in an economic downturn, how do you prioritize which tests are going to research? Is it crop related, is it pathology? How do you prioritize the need for testing?

MICHAEL MUSCHICK: Our priorities are that we are in constant consultation with our stakeholders and from there we are getting the information what is required on the one side to facilitate the seed trade; on the other side there are the needs and the requirements of governments which we are taking into consideration, and this is where we define our priority list; then we use the resources we have to address these questions.

KATALIN ERTSEY: Thank you. I have one more remark about the participation of the private laboratories, because since the 2004 Budapest Congress, the ISTA Accreditation Standard and the ISTA Accreditation and Quality Assurance System are free also and open - not free but open - for the company and private company and independent private laboratories as well. And I think if we follow the results of the proficiency tests and we see the results from the accredited laboratories, then we can see that these participations from the private side, I think it was a benefit also for all the seed sectors. I think that now the share of the private laboratories is about 25% in our Association and I hope we can value this project as well. Thank you.

BUILDING CAPACITY IN SEED QUALITY ASSURANCE IN DEVELOPING COUNTRIES

Mr. MICHAEL LARINDE*

Introduction

In this era of rapidly changing global conditions and increasing food insecurity, improved varieties and good quality seeds are required, more than ever, to confront the challenges that the changes bring. Improved seed is the carrier of technological innovations and serves as an engine for agricultural advancement when available in the required quantities and of the right quality. As in the past, the pivotal role that seed plays in national food security arrangements makes it a commodity for trade and politics. Improved seed is also an important agent for technology transfer. In all its various contexts, however, the quality of seed is crucial if it is to meet the full requirements expected of it. Indeed, in seed production and supply activities, seed quality constitutes a more serious source of concern than seed quantity.

Seed quality assurance is a mechanism put in place to guarantee the quality of seed from production, harvesting, and post-harvest handling through sales. Seed quality assurance is a systematic and planned procedure for ensuring the genetic, physical and physiological integrity of the seed delivered to farmers.

The term "seed quality assurance" implies that agencies charged with seed quality cooperate with and support stakeholders in other areas of the seed industry to assure quality products. Some of the basic objectives of quality assurance are the prevention of chronic troubles, diagnosis of such troubles and development of appropriate remedies for their resolution. Overall, elements covered by seed quality assurance include variety release, proper land selection, field crop inspection, seed testing and seed control (pre- and post-control). In these elements, four important seed quality parameters - genetic purity, physical purity, physiological condition and seed health status - are the focus.

The rationale for seed quality assurance includes, among others, the need to:

- ensure that the best quality seeds are produced and sold to farmers;
- prevent the spread of weeds, pests and diseases, particularly the invasive types;
- meet consumer demands for specified qualities;
- cater for the needs of specialized farming;
- comply with mechanization of agriculture; and
- provide the basis for healthy competition among seed traders.

To carry out effective capacity-building for seed quality assurance, a holistic approach is required. First, the assessment of various components of the seed industry, at whatever stage of development, needs to be properly conducted. Second, there is a need to ensure the development of adequate linkages between the components. Third, a good coordination mechanism needs to be established. Fourth, it is essential to have and pursue a program for human resource development in order to ensure the deployment of the needed skills. Fifth, it is essential to install facilities and equipment, particularly for quality checks. Last but not least, formulation and application of norms, standards and guidelines and legislation where applicable will be essential.

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State Of Quality Assurance Systems in Developing Countries.

In the 1970s through the late 1980s, the green revolution in Asia spurred donors to fund a wide range of seed projects in developing countries. Most of these projects contained a good range of elements of the seed industry; several seed technology institutions in developing countries played prominent roles in the provision of training in this "new field of agronomy". These training efforts yielded very positive results in advancing the knowledge of seed and fostering the development of the seed sector in developing countries, particularly in Asia.

Unfortunately from the 1990s, resource support to knowledge and training institutions active in seed-technology training, particularly those targeting Africa, started to wane, leading to the discontinuation of the pioneering training efforts. Further, investments in the seed sector in developing countries from donor countries and international organizations decreased, resulting in a rapid degradation of key infrastructures and institutions of the seed sector, particularly seed quality assurance systems, such as seed laboratories and seed-processing plants. Most of the seed technologists trained in the 1970s and 1980s gradually reached retirement age or moved to higher career levels in different fields not related to seed. This created a gap in seed knowledge in developing countries. This gap resulted in reduced capacity and capability in developing countries with consequent decline in the availability of good quality seed to farmers. To fill the technology and knowledge vacuum, the private seed sector, especially the multi-nationals, started to make provision for the training of their staff within their own resources.

In order to assess the capacity-building needs of member countries, FAO has established or collaborated in the establishment of some databases/information systems, shown in Appendix 1. A summary of seed sector analysis in developing countries shows that they are at varying stages of development - between and within sub-regions - on issues related to seed quality assurance. In addition, there is marked variation in the levels of quality control arrangements based on crops – being more elaborate and sophisticated for commercial crops than for non-commercial food security crops.

A recent survey carried out in 22 African countries to assess the stage of seed quality assurance in Africa, reveals a general need for capacity-building in several aspects of the discipline as shown in Table 1 below.

Table 1 Percentage of Countries with their Respective Level of Development in Key Aspects of Seed Quality Assurance (Based on a FAO survey in 22 countries)

Item	*Percentage of countries with a reasonably high level of development*
Existence of national seed policy	18
Seed legislation	23
Availability of variety development program	55
Variety release system	41
Variety release committee	45
Seed conditioning plants available	59
Seed quality control and certification	68
Official seed-testing laboratories	73
Trained inspectors and lab technicians	59

The survey found that often one aspect of quality control might be over-emphasized while other equally important ones were neglected. In extreme cases, countries make inappropriate seed laws thinking that legislation is the panacea for all seed quality problems. This often results in restriction of inflow of good quality seed from outside or leads to the public sector seed producers being favored at the expense of the private seed sector. This eventually leads to the monopoly of the seed sector by the public sector and resultant inadequacy of good quality seed for farmers. The survey also identified varietal release, legislation and seed crop Inspection as components of seed quality assurance which are particularly weak.

Other constraining factors in quality assurance assistance in developing countries relate to inconsistent funding, inadequacies in trained staff and limited equipment.

FAO's Capacity-Building Activities in Developing Countries

FAO's core activities relating to capacity-building in quality assurance include assistance to develop the following:

- national varietal release system;
- early-generation seed production system;
- structured training program for stakeholders of the seed sector;
- review and drafting of appropriate seed legislation and regulations;
- national seed policy;
- harmonization of seed rules and regulation at regional and sub-regional levels;
- seed quality control schemes, such as certified seeds, Quality Declared Seed (QDS)[1] and Quality Declared Planting Materials (QDPM)[2].

In regards to the above, FAO interventions, in cooperation with our international partners, target three main areas that must be taken into account in order to achieve a balanced and holistic development. The three areas are a) development of physical structures/facilities, b) human resource development and deployment, c) formulation/review of policy, legislation, guidelines, standards, etc.

FAO cooperates with reputed national and international organizations from both the public and private sector to carry out capacity-building in seed quality control. The partner organizations include the International Seed Testing Association (ISTA), the Seed Schemes of the Organization for Economic Cooperation and Development (OECD), the Union for the Protection of New Varieties of Plants (UPOV) and the International Seed Federation (ISF).

Over the past 10 years, FAO has executed 897 seed-related projects in which capacity-building was a major theme, at a total cost of 822.5 million US dollars.

These interventions include:

1. Emergency Seed Relief and Rehabilitation

FAO has dramatically increased its interventions in emergency situations in the last 10 years. The interventions generally include seed relief operations to restart agricultural production after both man-made and natural disasters. Quality assurance measures are a key element in these operations and are aimed at ensuring that:

a) seeds of crop varieties adapted to farmers needs are procured for distribution;
b) the seed lot meets minimum seed quality standards;
c) seeds comply with phytosanitary requirements in line with the IPPC Convention.

FAO has developed tools for ensuring that the quality of seeds used in emergency seed relief operations meets acceptable minimum quality standards. These standards have been established in consultation with international experts. Also, regional crop calendars have been developed to ensure timely seed delivery and appropriate variety identification. To support the progression from emergency to rehabilitation, efforts have also been made to strengthen in-country seed quality evaluation systems through the establishment of seed laboratories. By such interventions, FAO strengthens technical and logistical capacity/capability of recipient countries. Success stories in this regard include the establishment of private seed enterprises in Afghanistan from the pieces left in the aftermath of two decades of strife; and the restoration of the seed delivery system in Sierra Leone after the war in that country.

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[1] FAO designed the Quality Declared Seed as a quality control mechanism which is less demanding on government resources than seed certification but is adequate for providing good quality seed both within countries and in international trade. It is not a substitute for normal seed certification but a system put in place pending the ability of countries to have the requisite facilities and logistics for seed certification. The system relies on four principal points: 1) A list of varieties eligible to be produced as Quality Declared Seed is established. 2) Seed producers are required to register with an appropriate national authority. 3) The national authority will check at least 10 per cent of the seed crops. 4) The national authority will check 10 per cent of seed offered for sale under the designation Quality Declared Seed.

[2] Quality Declared Planting Material (QDPM) is a process for the production of clean disease-free planting material of vegetatively reproduced crops, primarily implemented by seed producers at community level or field extension workers. It has the final objective of significantly raising the current levels of physiological and phytosanitary quality of the plant reproductive materials available to smallholders, and as a consequence, an increase in agricultural production and productivity.

2. National Seed Program Development

FAO has assisted in the development and rehabilitation of national seed programs, aiming at enhancing the efficiency of the seed delivery system, establishment of an efficient seed quality assurance and assuring the seed security of farmers.

These activities have been organized in cooperation with national governments, regional and international organizations and, lately, also with the private sector. They include:

a) varietal characterization, registration and release;
b) development of systematic seed multiplication programs with essential elements of seed quality control;
c) establishment of both administrative and legal instruments for operating seed quality assurance;
d) review of seed legislation and regulations;
e) development of appropriate seed standards;
f) provision of appropriate equipment; and
g) provision of appropriate training for the stakeholders concerned.

FAO has trained more than 10,000 beneficiary seed-industry stakeholders in the last 10 years at different levels of seed activities. Various methodologies have been used for the training of seed-industry personnel in building up the capacity in quality assurance in developing countries. These capacity-building efforts included in-country training sessions, regional workshops, and overseas fellowships, including study tours. In addressing training needs, FAO complements its own internal expertise with additional competences from international experts drawn from FAO international partners, such as the International Seed Tasting Association.

3. Harmonization of Quality Assurance Systems

Discrepancies in seed quality standards and regulations are a major constraint to the development of the cross-border seed trade in developing countries. This hampers the development of seed enterprises in developing countries. Therefore, a key activity of the FAO in the last 10 years has been the harmonization of systems for seed quality assurance. Elements of quality assurance that were harmonized include:

- procedures for varietal release and registration,
- rules and procedures for seed quality control;
- plant quarantine procedures; and
- a plant variety protection system.

A major output of the harmonization activity is the development of the West African Catalogue of Plant Species and Varieties; and the harmonized seed regulatory framework which has been adopted by the ECOWAS Council of Ministers.[3] Harmonization of seed regulations has also been supported in the SADC region.

4. Development of Biosafety Programs

FAO has assisted member countries in developing administrative and technological tools for quality assurance of biotechnological products. The outputs included strengthening of seed-testing laboratories to detect adventitious GMO in traded seeds and foods as well as the establishment of procedures to facilitate co-existence of multi-track seed production systems such as conventional /organic/GM crops.

5. Development of Quality Control Schemes

FAO has developed a quality control scheme Quality Declared Seed (QDS), which provides an alternative for seed quality assurance, particularly designed for countries with limited resources, which is less demanding than full seed quality control systems but yet guarantees a satisfactory level of seed quality.

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[3] *www.fao.org/docrep/010/i0062e/i0062e00.htm.*

The QDS system, elaborated by FAO in 1993 for agricultural crops and revised in 2006, has been widely used and consulted. The QDS guidelines/protocols are aimed at assisting small farmers, seed producers, field agronomists and agricultural extension personnel in the production of quality seed.

In spite of the fact that systems are available for quality control of crop propagated by true botanical seed, less attention has been paid in the international arenas to the development of good procedures for the supply of vegetative planting materials, particularly of under-utilized crops, including some of the food security crops of developing countries. To address this gap, FAO has partnered with the Potato Improvement Centre (CIP) and other international experts to develop the Quality Declared Planting Materials system (QDPM) of selected vegetatively propagated crops. The 14 vegetatively propagated crops covered by the scheme are potato, cassava, sweet potato, banana, plantain and other musaceae, cocoyam, garlic, oca, ulluco, mashua, konjac, hausa potato, taro and yams. Publication of this scheme is expected in 2009.

Constraints of Capacity-Building and Future Considerations

Constraints

Over the years, FAO capacity-building activities have expanded to cover newly emerged contemporary topics. The main constraints encountered in FAO efforts aimed at capacity-building for seed quality control are:

- Limited resources to establish/procure necessary infrastructure required to provide essential facility and a critical mass of the workforce required for effective seed quality control.
- Limited interest shown by many countries and donors in providing necessary financial support for specialized seed institutions including knowledge and learning centers.
- A lack of opportunity for sponsored training in the areas of importance for seed-industry development.

Much of the future efforts in seed quality assurance for Africa will take place under the newly adopted Africa Seed and Biotechnology Programme (ASBP), which is a continent-wide seed development program and framework under the ambit of the African Union.

Future Considerations

In order to build the capacity for a quality assurance system in developing countries, there will be a need to examine the following issues.

Need for Long-Term Sustainability of Project Outputs

In several instances, serious reverses have occurred upon project termination. There is a need to put good exit strategies into project designs and implementation of the project to enable national efforts to sustain the outputs generated by projects. Often this would require an ambience of facilitating seed policy and effective institutional arrangements. Since the quality assurance effort depends largely on public funding, a systematic incorporation of efforts from the private sector where it is developed will reduce the burden on the state and enhance sustainability.

Appropriate Infrastructure

Data on infrastructure for seed quality assurance, particularly seed-testing laboratories and appropriate storage, indicate gross inadequacies in many parts of developing countries. There is a need for governments to recognize the key role played by quality assurance and to allocate on a priority basis, adequate infrastructure to complement the seed-testing equipment they inherit after the project's activities have ended.

Training

There is serious inadequacy in seed training in the developing countries. Aside from appealing for the resumption of accelerated seed training in developed countries, there is a need to establish credible seed training and knowledge centers in the developing countries, where knowledge and experience with local problems will be an advantage in preparing trainees to fit into the local context.

Regional Networking and Coordination in Laboratory Seed Testing

In view of limited resources, national seed quality assurance programs will achieve much more if they cooperate in referee testing and training within the ambit of harmonized protocols. Often neglected food security crops could benefit from such networking, as would also the intra-regional seed trade.

Policy and Legislation in Relation to Quality Assurance

The formulation and adoption of appropriate policies and legislation establishes the seed quality assurance as the credible basis for the seed sector, provides a level playing field for all actors and can serve to improve investments in the seed sector

Cost-Effective Methodologies for Seed Quality Assurance in the Informal Sector, Participatory Breeding

Since an overwhelming portion of seeds in developing countries emanates from the informal sector, the effective introduction of seed quality assurance to that sector is likely to make a big impact on crop production and strengthen food security. Other areas, which will also benefit from the introduction of good quality assurance activities, are participatory plant breeding, preservation of valuable ecotypes, the operation of community seed banks, etc.

Acknowledgements

I hereby express my gratitude to all the colleagues of AGP who in various ways provided information and contributed to the development of this paper. In particular, I wish to recognise the great efforts of Mr. Philippe LeCoent who critically reviewed the earlier drafts and Mr. Josiah Wobil for making many critical field-experience-based suggestions, which have greatly enriched this paper.

References

FAO, 2006. Quality Declared Seed System. Technical Guidelines for Standards and Procedures. FAO Plant Production and Protection Paper 185. FAO, Rome, Italy.

FAO, 2009. Quality Declared Planting Material System. Technical Guidelines for Standards and Procedures. FAO Plant Production and Protection draft publication. FAO, Rome, Italy.

Douglas Johnson, E. 1980. Seed Quality Control. In: Successful Seed Programs: A Planning and Management Guide; pp. 109 - 142.Westview Press, Boulder, Colorado, USA.

Appendix 1

Selected FAO Tools for Seed Quality Assurance

On-line database of pasture/forage resources in more than 80 countries.

Ecocrop: Identify a suitable crop for a specified environment, identify a crop with a specific habit of growth, identify a crop for a defined use or look up the environmental requirements and uses of a given crop.

Grassland Index: Allows searches of more than 600 grass and forage legume species by genus, Latin name and common name

Hortivar: Database on performances of horticulture cultivars in relation to agro-ecological conditions, cultivation practices, the occurrence of pests and diseases and timing of the production.

Nutrient Response Database: Database allowing for the extraction of yield data per agro-ecological zone for the main food crops in a specific country. The extracted data enable the estimation of fertilizer input and crop output ratios for projection of future fertilizer application to support increased crop yield targets.

World Information and Early Warning System (WIEWS): The World Information and Early Warning System (WIEWS) on Plant Genetic Resources for Food and Agriculture (PGRFA) was established by FAO as a worldwide dynamic mechanism to foster information exchange among member countries. This website gathers and disseminates information on PGRFA, and acts as an instrument for the periodic assessment of the state of the world's PGRFA. It consists of a Global Network of **Country Correspondents on PGRFA's Information Exchange** and a number of relational databases including an ex-situ collection, PGRFA and Seed Laws and Regulations, the World List of Seed Sources and List of Crop Varieties. *http://apps3.fao.org/wiews/wiews.jsp*.

All workshops, training opportunities within capacity-building projects are fully advertised among stakeholders mainly online though the FAO website and through partner websites: *http://www.fao.org/ag/AGP/AGPS/default.htm*.

All biosafety-related capacity-building training courses, projects and workshops are included in the FAO Biotech Newsletter and in the biosafety capacity-building database of the Cartagena Protocol on Biosafety.

All publications such as manuals, methodologies, technical outputs are disseminated to the participants and to the stakeholders.

Discussion

IR HINDARWATI: My name is Hindarwati and I am from Indonesia. I think quality assurance is the most important part of the seed industry, because it is to ensure that the quality of seed is true in terms of variety and also good in terms of quality from the producer to the seed user. Do you have any research done by FAO on how if we have like not just quality assurance, but quality insurance, so then if the quality of seeds is not true for the seed users, then if any of them pay any costs; is there a cost?

MICHAEL LARINDE: Well I must say that this is not - sorry - I must say that this is not handled in the quality assurance, but we handle this through a system to countries in drafting their seed policy and reviewing their seed legislation. Actually I came back from Iraq about 10 days ago to finalise this kind of thing. There must be appropriate seed legislation to make seed quality assurance work in the real sense; in that violators have to face a penalty. And this must be ensured in the law, not in the lab. I don't know if I answered your question. It has to do with the policy of the government as well as the legislation in the country. And this is why in FAO we have a legal department that works together with the seed service and both departments help member countries to review their seed laws and to draft appropriate legislation for them, because you don't want a seed law that will restrict incoming materials into your country. That's counter-productive, but at the same time you need a seed law that ensures equity in that they show that the interest of the consumers as well as the sellers are taken care of. In fact that is the basis of seed testing; one reason seed testing was developed, to ensure that there is this kind of way to judge something and then appropriately take precaution. Thank you.

IR HINDARWATI: I suggest that – excuse me – I suggest FAO will have research on this. Thank you.

KATALIN ERTSEY: I would like to take some additional remarks on this topic, because I think if you can reach to include in your country the quality assurance in the legislation, then after that it is easier to apply for insurance or to reach a reasonable situation, because then in the legislation is included that they should have quality assurance; there is some requirement and you can apply for that. I think so.

ZEWDIE BISHAW: Zewdie Bishaw from ICARDA. I am seed technologist and I can help out how to leave the situation. I am enough clearly elaborated on the relationship in terms of quality assurance and the need for training in quality assurance. I understand the need for training is clearly elaborated for quality assurance. But would it not be more useful if we broaden the issue of training in terms of seed sector development as a whole, looking into the production and marketing aspects and other issues, not only on quality assurance?

MICHAEL LARINDE: Thank you, Zewdie. Actually we have done a lot of things in this area, but this is not my topic today. That's why I did not make reference to this, but as you know, apart from all those things I listed we have been involved in developing national and regional seed associations, and this is to facilitate communication and collaboration among seed stakeholders and so on and so forth. And also we have done all over the world in each region regional workshops in collaboration with ISTA on GMO seed testing and detection, because we realised even though many countries don't want GMO, if they have adventitious presence of GMO in their seed, they should have this way of testing, and most of these countries don't have. And so in that sense we also have to train them, and also at the seed association level we work very closely with APSA - because APSA is an FAO baby, just like ECOSA has become one - and we facilitate their training for the private seed sector in Asia in the area of seed health testing, in the area of GMO detection, as well as regular seed quality control. So I didn't mention everything, but I am restricted to the topic given to me. Thank you.

OBONGO NYACHAE: Thank you very much. I am Obongo Nyachae from the Seed Trade Association of Kenya, and I also coordinate a programme on harmonization of seed policies and regulations in Eastern Africa. Now I have one question: from your presentation and from the presentations of the previous speakers, it is very clear that to improve productivity - especially I am talking now of Sub-Southern Africa - it is very vital, that FAO as the media organisation which is trusted, and FAO has one good aspect, it is trusted by many countries. Because of that trust, you come up with a system of quality declared seed and you know very well that maybe you do not have the promoters presented in the history of seed testing. It has taken many, many years here in Europe, in America and elsewhere, to develop a quality assurance system. Why does FAO spend – you put the figure there of 800 million US dollars, nearly 1 billion US dollars, to preach a system that you know very well is only serving that time, that is not sustainable? Why not work with the private sector more, so that if you have to sustain a system then use the government, the systems already established in those countries, seed trade associations, so that seed is actually seed and is not just something called "quality declared"; it should be seed meeting the aspect. So why does FAO spend these enormous resources which do not yield as much fruit?

MICHAEL LARINDE: Thank you for your comment. The point is well taken but I will not agree that it does not bear fruit, for the following reasons: Rome was not built in a day, and you cannot jump – a baby has to crawl before it can walk and before it can run. You have many countries, there is nothing. If you want to develop the classical system of certification, you need a critical mass of trained people, you need massive injections of funds to set up the facilities and you need a programme in place that will sustain the system. As it were, things worked very well in Europe, because many of these things are done on a sustainable basis. In the 1980s I refer to, many of these were donor-funded and some even said you may distribute the seed free. These are some of the things we are trying to amend, we are trying to work and find a way around, and this is why even now we have a programme, where we are trying to link seed production to crop production and to value addition. Because that is the only way for farmers in Africa; when they have the crop, everything they sow that is raw material, and the price goes down, but if you have value addition, then farmers will all be able to make a reasonable profit and they will be willing to buy seed and that's when you can talk of the very top class system. I must add, finally, that even with that system, Afghanistan sat there with quality declared seed, and now they are producing certified seed. Because they have progressed and they are now producing certified seed. Thank you, I am told my time is up.

RAISING SEED QUALITY: WHAT IS IN THE PIPELINE?

Mr. JOOST VAN DER BURG[1]

Summary

This presentation gives a short overview of some of the promising technologies that are still under development or that have recently become available. They comprise technologies that are used for seed research, seed testing, seed enhancement and seed sanitation. Recent developments include X-ray research of seeds, chlorophyll fluorescence of dry and imbibing seeds, oxygen production, ethanol production, grass seed priming, and electrification. Molecular technologies are briefly discussed, including flow cytometry, genomics, proteomics and metabolomics.

Introduction

A short inventory has been made of the most promising technologies that are either in the pipeline or have happily emerged and are now available for use. The technologies usually involve quite some investment and they sometimes take a decade or more to mature, so it is understandable that some secrecy surrounds them until the protected product can be shown to the public. So, the overview may be missing out some technologies, either by choice or by unawareness.

What does "raising seed quality" mean? Seed quality includes many aspects such as germination capacity, speed of germination, uniformity of germination, vigor, absence of pathogens, increased natural defense, provision with protectants, etc.

Seed quality has both physical/physiological and genetic elements. Genetic improvement, or breeding, has been dealt with in other papers during this Conference and will therefore not be included here.

Of course there is no better way to produce good seed other than in the field. But failing this, it is up to seed technologists to try to rescue as much as possible.

If we try to categorize the various technologies, then we come to these main entries: tools for seed testing and research; sorting technologies; methods for seed enhancement, sanitation and the addition of chemical compounds, biologicals and the like. Hereafter, you will see that many technologies are combinations of these. In this paper we will present a selection under two headings: seed testing and research and enhancement (which includes sorting, priming and sanitation).

Seed Testing and Research

A large number of exciting technologies are in the pipeline or have come recently to our disposal and we will have a short look at some of them.

X-ray

X-ray research has long been a tool for seed analysts, but it always involved films which needed developing and visual inspection by a person. With the ever-increasing speed and capacity of computers and the development of high-resolution imaging chips, the automation of this process becomes a reality. The systems can be made so fast that sorting of tomato seeds is now possible and offered commercially (Incotec International BV, Fig. 1)

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[1] Plant Research International, Wageningen University and Research Centre, in collaboration with Mr. Jan Bergervoet, Mr. Steven Groot, Mr. Henk Jalink, Mr. Jan van der Wolf

[2] Mr. Johan Van Asbrouck, Astec Global

[3] Mr. Bob Legro, Incotec International BV

[4] Mr. Harry Nijënstein, Innoseeds BV

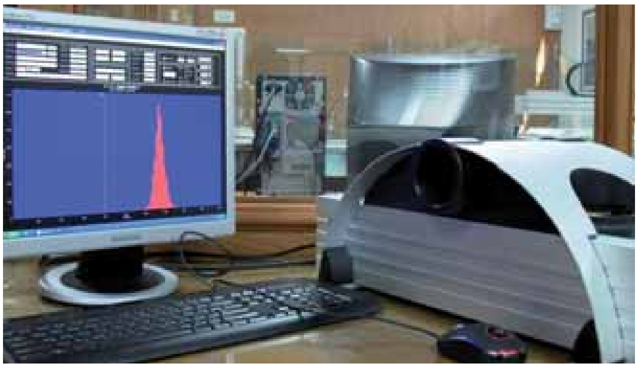
Fig. 1 Real-Time Sorting Machine using X-rays and Image Analysis (Source: Incotec International BV)

Another application of X-rays in combination with image analysis has been developed for crack detection in maize seed (Cicero et al. 2000).

Chlorophyll Fluorescence of Dry Seeds

It is a little over 10 years ago that we started research on chlorophyll fluorescence of seeds (Jalink et al. 1998). It was found that with this technology we could detect chlorophyll in almost every seed, and that levels differed considerably. And the good news was that these levels were a measure for something we could not measure before: seed maturity. Since we know that maturity correlates strongly with quality aspects like germination, speed of germination and seed health, this technology could develop into something important. Fig. 2 shows the laboratory analyzer which is commercially available (Astec Global).

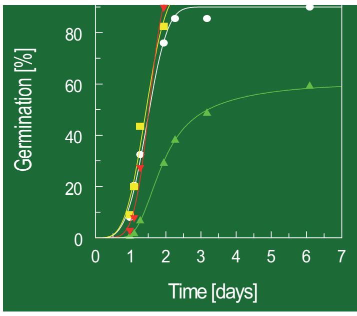
Fig. 2 Chlorophyll Fluorescence Tester for Dry Seeds (Source: Astec Global)



The technology is based on exciting seeds with a laser beam and measuring the resulting fluorescence: this fluorescence decreases with maturity. Less mature seeds show higher levels of fluorescence and have therefore higher levels of chlorophyll than fully mature seeds. The technology has now become so fast that we can analyze seed-by-seed in milliseconds and build it in color sorters. Discussions with a manufacturer are at an advanced stage.

Fig. 3 illustrates the importance of seed maturity. A paddy seed lot was separated with an original germination of 90 per cent into three fractions. In the left graph their germination time courses are compared with the white control. The green lower line represents the fraction with high CF, so it consists of the less mature seeds. This fraction represents 13.5 per cent of the lot (Table on the right). It has a germination percentage of only 60 per cent. By removing this fraction from the lot, germination would increase to 97.5 per cent.

Fig. 3 Germination



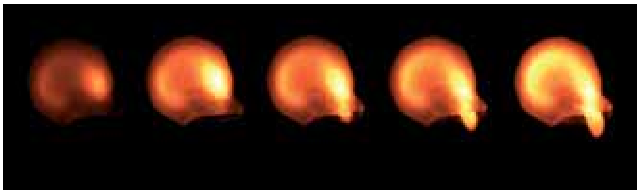
control		90.0	84.0
high	13.8	60.0	56.5
medium	33.5	97.5	91.0
low	52.7	97.5	93.5

Time courses (left) of three CF fractions and the original sample of paddy seed. Results of the germination tests (right): size of the fraction, total germination, percentage normal seedlings. High (green characters and graph) is less mature seed, low (red) represents fully mature seed. (Source: Plant Research International)

Chlorophyll Fluorescence of Germinating Seeds
A second development with CF of seeds is not just to measure the seed as a whole and obtain one figure, which is already quite informative, but to get values from over the entire surface of a seed: that is to say create a fluorescent image. Ideally this should again occur in an automated way and with large numbers of seeds at a time.

A set-up was created with high resolution cameras and special filtering producing the images in Fig. 4. It represents one pepper seed in a time sequence of 48 hours.

Fig. 4 Chlorophyll Fluorescence of Germinating Pepper Seed showing Differential de novo Synthesis of Chlorophyll in a Seed Embryo. (Source: Plant Research International)



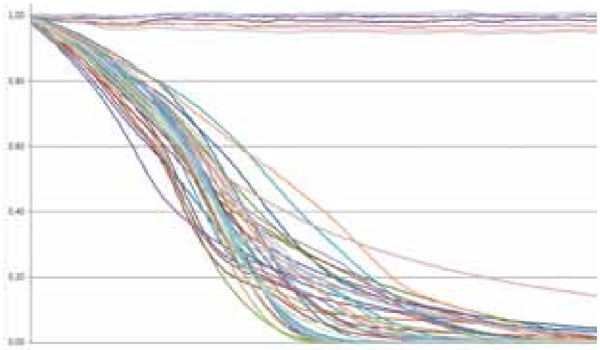
New technological developments make new applications possible. In dry and fully mature seeds the level of chlorophyll is relatively low, as we have seen; as soon as seeds start to imbibe, de novo synthesis of chlorophyll takes place. In this pepper seed the strongest signals come from the elongating hypocotyl and root base, followed by the cotyledons. This technology can, apart from being used for research purposes, also be developed into automated seed germination tests. CF provides ultra-clean images of seeds without background, which are ideal for image analysis.

Q2 Technology

A totally different approach is given by measuring gases. The first example is the use of oxygen consumption by seeds as parameters for seed viability and vigor.

Seeds, and certainly germinating seeds, breathe, although plants at this stage use oxygen rather than produce it. The Q2 technology uses the wells of ELISA plates in which seeds are placed individually. The cells are covered with a specially coated foil, which if excited with a laser, produces fluorescence. This fluorescence is influenced by oxygen and results in a measure of the oxygen content of the cell. The process is fully automated and many plates can be followed at the same time.

Fig. 5 Curves showing Oxygen Depletion of 96 Seeds (Source: Astec Global)

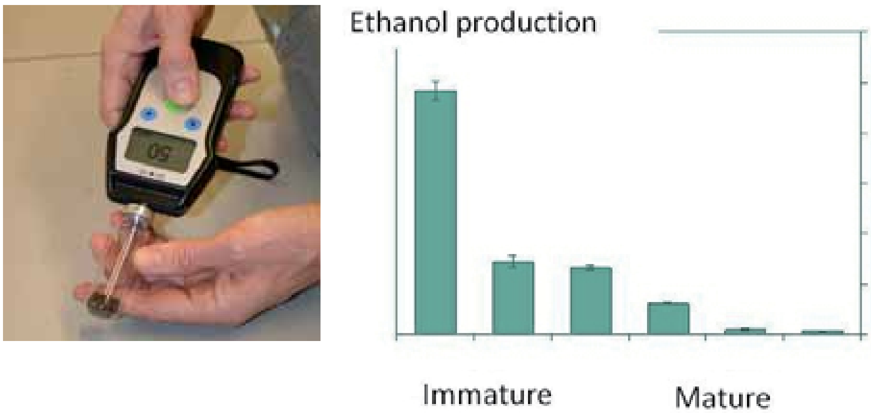


Seeds normally completely exhaust the oxygen present in the cell in a time span of 48 hours, resulting in S-shaped curves as shown in Fig. 5. The upper curves, however, where the oxygen hardly decreases are filled with dead seeds. Intermediate values are obtained when seeds are of low vigor. Curve-fitting algorithms of the various shapes of the curves allow extraction of a number of solid parameters per seed, and thus a prediction of, for instance, vigor, field performance and total germination.

Ethanol Assay

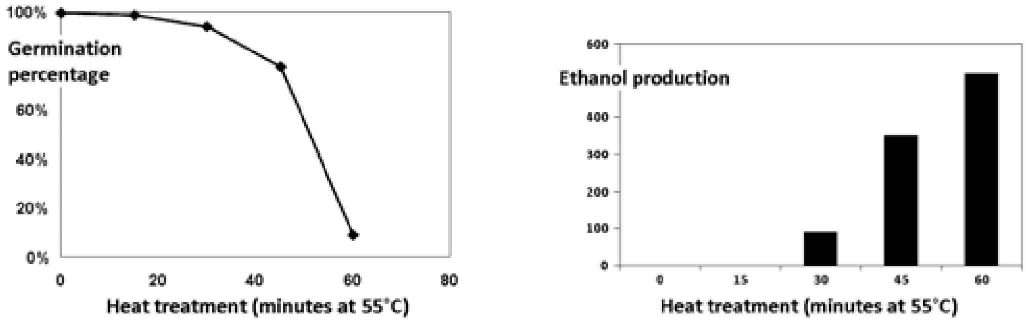
Another gas-based technology uses the production of ethanol vapor by seeds (Fig. 6). This very new technology is based on the fact that when seeds deteriorate they disintegrate slowly under the production of ethanol. The measurements are made with a slightly modified breathalyzer, as is normally used by traffic police. Measuring ethanol in a test tube in which the seeds have been put for some time, shows clear differences between different quality groups. In the right-hand graph you can see that the more immature the seeds, the more ethanol they exhale, indicating seed deterioration and lack of vigor. This increased production of ethanol in less mature and immature seeds is explained by damage to the mitochondrial system, possibly due to reduced membrane integrity and subsequent oxidative stress, resulting in a blockage of the Krebs cycle and subsequent production of acetaldehyde and ethanol.

Fig. 6 Using a Breathalyzer to measure Ethanol Production by Seeds. Immature and Less Mature Seeds produce more Ethanol than Fully Mature Seeds (Source: Plant Research International)



The ethanol assay can be used to monitor and optimize seed treatments. We have experimented with the hot water treatment of cabbage seeds; an important tool for environmentally safe sanitation of seeds (Fig. 7). In the left graph we see a rapid decline in quality during the heat treatment. From the outside the deterioration of the seed cannot be seen, so one knows only after it is too late. Ethanol measurements of tiny quantities of seed can be used to optimize this. In the graph on the right we see that ethanol appears at the moment that the germination starts to decline after 30 minutes. So with a little shorter treatment one is at the safe side.

Fig. 7 Germination Decline during Heat Treatment (left) and Ethanol Production of the Same (right)
(Source: Plant Research International)



The ethanol assay also proved to be a good marker for deterioration during seed storage. As soon as the germination speed of cabbage seeds decreased, the production of ethanol markedly increased. In this way the assay can be used as a monitoring tool and helps to decide what to do with the lot.

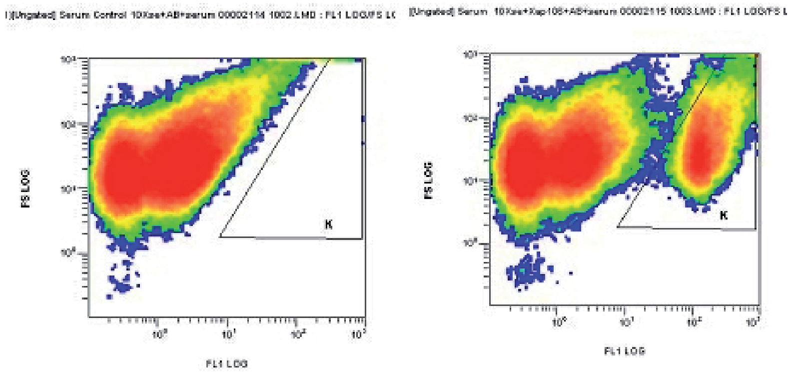
Molecular Technologies

We will now briefly touch upon some technologies used for the detection of pathogens. Several are based on immunofluorescence, like the well-known and widely used ELISA method. Modern versions of this principle have been developed to speed up the process and also to enable the measuring of various pathogens at the same time: i.e. multiplexing.

Flow Cytometry

To enhance detection of seed-borne viruses and bacteria, flow cytometry (FCM)-based techniques were developed. (Fig. 8). FCM enables multiparameter analysis and quantification of particles, such as bacterial cells and fungal spores. Particles are analysed on the basis of size, granularity and emission of fluorescence, if particles are autofluorescent or have been stained with a fluorescent probe. We developed FCM immuno-detection procedures for *Xanthomonas axonopodis pv. phaseoli, X. campestris pv. campestris* and *Clavibacter michiganensis subsp. michiganensis* in seed extracts.

Fig. 8 Flow Cytometric Analysis of Seed Extracts of Beans showing Presence of Xanthomonas axonopodis
(Source: Plant Research International)



Luminex® MAPS

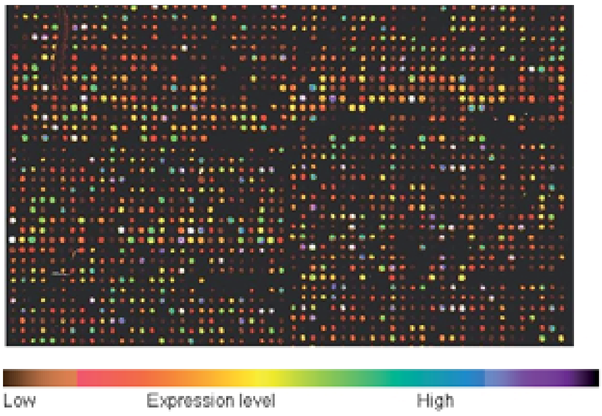
We also explored the potential of the Luminex® MAPS technology for multiplex detection of seed-borne viruses and bacteria. This technology is based on the use of antibody coated paramagnetic microspheres (immunobeads), internally stained with fluorochromes. These beads act more or less as microscopic ELISA-wells. We developed an assay for the detection of several viral pathogens including lettuce mosaic virus and pepino mosaic virus. The assay was performed in 96 wells microplates and could be completed within 60 min. The detection level for bacteria and viruses was similar to that of a DAS-ELISA. The assay can be extended to a multiplex assay of up to 100 different pathogens.

Fig. 9 Luminex® Apparatus for High-Speed throughput Analysis using Immunobeads (Source: Luminex Corporation)

Genomics

Other molecular approaches are based on DNA, proteins or metabolites.
A very powerful tool that looks at gene expression is the cDNA micro-array platform with 1536 spots on one slide. It shows the genes' activities at a certain phase of development, in a certain organ (leaf, root, flower parts, etc.) or of a particular developmental phase such as during seed maturation, germination, priming treatments, etc. Results include the identification of a subgroup of genes that are up-regulated during osmopriming and germination and are down-regulated again during drying. These can be used to fine-tune the priming and re-drying process.

Fig. 10 Gene Expression in cDNA Array with 1536 Spots in one Operation. (Source Soeda et al. 2005)

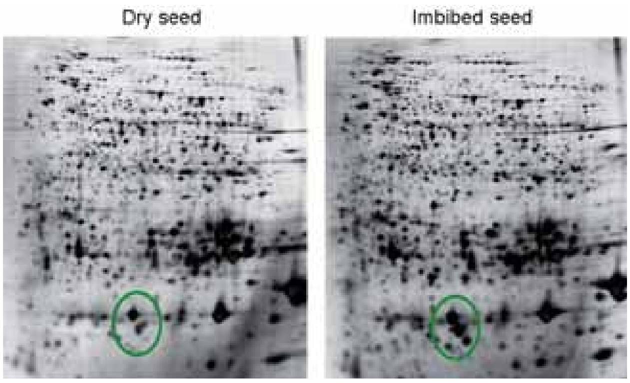


The technology can be used to create QTL-maps, which in turn are very useful for plant breeding and crop improvement.

Proteomics

Proteomics is the large-scale study of proteins, particularly their structure and function. Fig. 9 shows an example of a total stain of all proteins present in two seed extracts: on the left a dry seed on the right an imbibed seed. In the second slide we see the de novo synthesis of a protein which apparently plays a role in the initiation of the metabolism. In this way the up-and–down regulation of proteins can be studied to help us unravel complex developmental processes such as germination and to detect protein markers for seed vigor and priming.

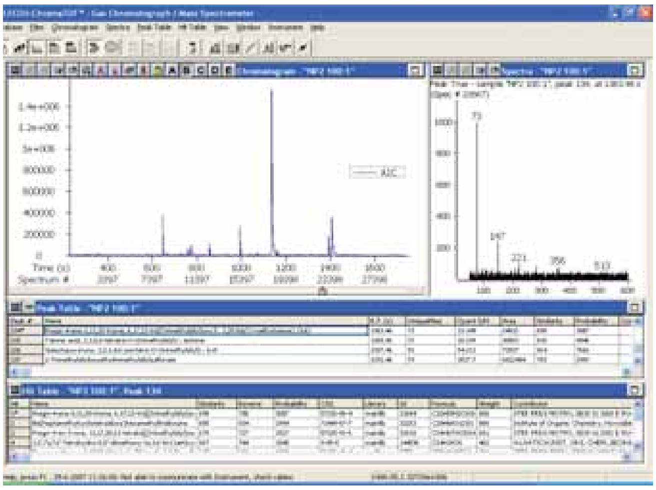
Fig. 11 Protein Profiles of Dry and Imbibed Arabidopsis Seed (Source: Gallardo et al. 2001)



Metabolomics

Finally we have metabolomics or the study of the final metabolites in a cell, metabolic mapping giving a snapshot of all cell constituents of a certain cell type at a certain moment in time, just like proteomics. The technology is quite different, however. In the old days we would use thin-layer chromatography; presently we have high throughput gas chromatographers - mass spectrometer combinations (GC-MS), producing up to 500 spectra per second. With this technology the role of seed oligosaccharides and anti-oxidants have been studied in relation to desiccation tolerance and seed longevity. Presently we are performing non-targeted metabolomics, so using the whole spectrum of metabolites in our research for private companies.

Fig. 12 GC-S Analysis of Seed Metabolics. (Source: Plant Research International)



Seed Enhancement

At the turn of the previous century experiments with the application of electricity to improve seeds had already been done. Charles Mercier (1919) reports on successful experiments and practical application of electro-chemical treatment on seeds: cereal and vegetable seeds. He talks about experiments using electrical currents through water baths enriched with electrolytes. This resulted in more vigorous growth and higher yields. It was in fact a combination of priming and electric treatment. The costs of such treatments were rather high in the early days of electricity.

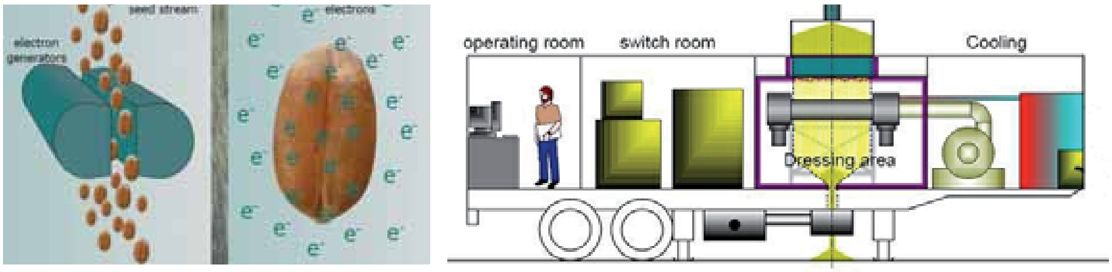
Priming of Grass Seed

A lot can be said about priming, but time is limited and I would like to mention one development which I found striking. Priming is common practice in many crops, especially vegetables, but in grasses it is relatively new. Grass is a rather bulky product; it is chaffy and for a long time one did not want to engage in wet treatments: the costs were also prohibitive. In recent years one started to use priming to speed up the germination of smooth-stalked meadowgrass, Poa pratensis, which is a notoriously slow germinator, in order to increase its chances of survival in sods grown from mixtures with faster-germinating species like Lolium perenne. Poa pratensis is essential because of its property to make stolons, resulting in stronger turf. PreGerm®-treated seeds germinate 5 to 7 days faster than untreated seeds and result in about twice as much presence in the turf.

Electrification

A modern version of the application of electricity on dry seeds has been developed in Germany (e-ventus™) and is based on seeds falling through a field with electrons, resulting in killing off most bacteria and fungi (Fig. 13). This is an environmentally safe method with no chemicals involved. It is now available as a movable unit in a truck with a capacity of up to 30t/h.

Fig. 13 Treatment of Seed with Electrons. Principle (left), Practice (right) (Source: Schmidt-Seeger)



Concluding

ISTA established the Advanced Technologies Committee a few years ago and is following these developments closely, trying to share them with our colleagues as soon as they are fit for seed testing or seed improvement purposes.

References

Cicero, S.M., Van der Heijden, G.W.A.M., Van der Burg W.J. & Bino, R.J. 1996. *Avaliação de danos mecanicos em sementes de milho por meio de analise de imagens* [Evaluation of mechanical damage in seeds of maize by image analysis]. p.229 in: *Congresso Nacional de Milho e Sorg XXI, 1996, Londrina Resumos*. Londrina, Brazil, *Instituto Agronomico do Parana (IAPAR).*

Gallardo, K., Job, C., Groot, S.P.C., Demol, H., Vandekerckhove, J. & Job, D. 2001. Proteomic Analysis of Arabidopsis Seed Germination and Priming. *Plant Physiol*. 126: 835-848

Jalink, H. 2000. Method for determining the maturity and quality of seeds and an apparatus for sorting seeds. *USA patent no. 6,080,950.*

Jalink, H., Van der Schoor, R.J., Frandas, A., Van Pijlen, J.G. & Bino R.J. 1998. Chlorophyll Fluorescence of *Brassica oleracea* Seeds as a Non-Destructive Marker for Seed Maturity and Seed Performance. *Seed Science Research 8: 437-443.* doi:10.1017/S0960258500004402.

Lush, W.M. 1987. Establishment of Turf using Advanced ("pregerminated") Seeds. *Aust. J. exp. Agric*. 27: 323-327.

Mercier, C. 1919. *A Manual of the Electro-Chemical Treatment of Seeds*. University of London Press.

Pill, W.G. & Korengel, T.K. 1997. Seed Priming advances the Germination of *Poa pratensis. Journal of Turfgrass Management 2: 27-43.*

Soeda, Y., Konings, M.C.J.M., Vorst, O., Van Houwelingen, A.M.M.L., Stoopen, G.M., Maliepaard, C.A., Kodde, J., Bino, R.J., Groot, S.P.C. & Van der Geest, A.H.M. 2005. Gene Expression Programs during *Brassica oleracea* Seed Maturation, Osmopriming, and Germination are Indicators of Progression of the Germination Process and the Stress Tolerance Level. *Plant Physiology 137: 354-368.*

Van der Burg, W.J., Aartse, J.W., Van Zwol, R.A. & Bino, R.J. 1994. Predicting Tomato Seedling Morphology by X-ray Analysis of Seeds. *Journal of the American Society for Horticultural Science 119: 258-263.*

DISCUSSION

ISMAHANE ELOUAFI: Ismahane Elouafi from the Canadian Food Inspection Agency. I wanted to just ask you a question about the flow cytometry. You showed the Luminex 100, that is the flow cytometry if I understood you well. So it's microbeads and is it based on hybrid? I just want to understand this a bit more. So I know it is a flow cytometry and you were talking about the Luminex 100 that uses microbeads, so I just want to know a bit more how you detect the different viruses. Do you have to have previous knowledge of the virus or the pathogen to use the machine?

JOOST VAN DER BURG: I hope I understood you question well, and you should rather ask my colleagues about this, but the microbeads are in fact a sort of medium to put your antigens and antibodies, like in ELISA. So it is not the well itself, but it is on a small ball, and this ball itself also shows fluorescence. And then depending on the normal technology that you use for ELISA, using different probes with different colours, different fluorescent colours, you can sort these beads.

ISMAHANE ELOUAFI: OK, thank you. It is different packaging of ELISA techniques?

JOOST VAN DER BURG: Different what?

ISMAHANE ELOUAFI: Packaging. It is just a different way to make multiple ELISA system, yes, OK, I thought it is a different thing. Thank you.

MAINTAINING CAPACITY IN SEED TECHNOLOGY AND SEED TESTING

Mr. J.G. HAMPTON*

Summary

The seed industry of the 21st century has a continuing need for seed technologists and seed analysts. However, there is a world-wide shortage of skilled people available to enter the industry. This shortage will increase as the drivers and leaders of today, the baby boomers, begin to retire. Attracting vibrant, energetic, passionate, motivated, creative and able young people from the Y Generation will be vital for the survival of the seed industry. Increasingly, governmental support for the seed industry and seed quality assurance is being withdrawn. The private sector must take an increasing responsibility for the long-term future of their own industry. The current situation is discussed and some options for the future are presented.

Introduction

Seed technology embraces breeding, evaluation and release, production and processing, storage, testing and certification of seeds (Feistritzer, 1975). It therefore encompasses aspects of agricultural practices which date back thousands of years. For example, prehistoric man knew and realised the importance of seed storage (Chin, 1991); the writings of Theophrastus (311-287 BC) cover seed germination, dormancy, viability and longevity (Evanari, 1984). However, it was not until the 19th century that national and then international seed trading developed, and the need to test for seed quality became evident (Hampton, 2002). Unscrupulous business practices and/or lack of knowledge by those involved in the marketing of seed in 19th century Europe and the Americas led to the first seed laws (e.g. the Adulterated Seed Act, 1869, UK) and the development of what Copeland and McDonald (1975) called "the art and science of seed testing". In 1869, Professor Nobbe published his Statute concerning the testing of agricultural seeds (Steiner and Kruse, 2007) and he established the world's first seed testing laboratory in Germany.

We have come a long way in the ensuing 140 years. Today the global seed market is around 37 billion US dollars, with seed traded internationally worth just over 6 billion US dollars (Bruins, 2008). This market has almost tripled over the last three decades (Le Buanec, 2007). Key drivers of this increase include the evolution of multinational seed companies, the increased availability of F1 hybrids, protection of intellectual property, an increasing use of counter-season production and the development of GM crops. Five companies now represent around 30% of the global seed market (Le Buanec, 2007).

In US dollar values, seed exports are dominated by The Netherlands, the US and France, and seed imports by the US and France (Bruins, 2008). Outside Europe and The Americas, only New Zealand, Japan, China, Australia, Thailand and South Africa make the list of the top 29 seed exporting nations, and Japan, China, South Africa and Australia the list of the top 29 importing nations (Bruins, 2008). This information is a reminder that the world's agriculture is still divided into "commercial and subsistence sectors" (Dominguez et al., 2001), and that there may be different needs between the developing and the developed economies. However, one need, the availability of quality seed, is common to both sectors.

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Capacity in Seed Technology

The seed industry of the 21st century, both in the developed and developing economies, has a continuing need for seed technologists. The New Zealand Grain and Seed Trade Association has noted that "the seed industry is short of skilled people" (Gerard, 2008). Positions within the industry recently advertised have included:

- plant breeders
- marketing assistants
- research technicians
- territory sales managers
- grain and seed representatives
- crop and pasture agronomists
- seed analysts

According to the ISF, this lack of skilled people is a global phenomenon (Bruins, pers. comm. 2009), both for the "old technologies" such as agronomy, and, in this "omics" era, the "new technologies" made available through advances in plant biotechnology. The seed industry requires tertiary qualified people with science degrees, preferably with an agricultural focus. Our industry offers wide career paths and the opportunity to specialise in research, production, management, marketing, sales, policy analysis, regulatory, finance and logistics (Gerard, 2008). So what is the problem? Why, with attractive career opportunities are there problems with obtaining suitably qualified candidates in the seed industry?

Tertiary Opportunities

At first glance, the answer may be that tertiary students cannot obtain the necessary seed technology skills. After all, the internationally known seed technology programs during the 1980s at Mississippi State University, US (Prof. James Delouche and colleagues), Massey University, New Zealand (Prof. Murray Hill and colleagues) and Edinburgh University, UK (Dr Mike Turner and colleagues) have either ceased to operate or have been significantly reduced in scale. However, as demonstrated in Table 1, tertiary training in seed technology at postgraduate diploma, masters and doctoral levels is still available around the world.

Table 1 Examples of Universities offering Postgraduate Qualifications in Seed Technology[1]

Region	*Country*	*University*
South America	Brazil	Universidade Federal de Pelotas
North America	US	Ohio State University
Australasia	New Zealand	Lincoln University
Asia	India	Bangalore University
Europe	Netherlands	Wageningen University

Lack of Students?

Is it difficult to attract students? The answer to this question will differ among countries, and between the developing and developed economies. In the former there appears to be keen interest in acquiring a postgraduate qualification in seed technology, if my own experience is mirrored by that of my peers. For several years now I have received over 50 emails per year from prospective postgraduate students from countries in Asia, Africa, the Middle East and South America wanting to undertake a Masters or PhD with me in seed technology. The majority have an undergraduate academic record which would give them admission to postgraduate study at my university. The problem is that only very rarely does an enquiry come in without the words "please arrange a scholarship for me so that I can become your student"! This I cannot do.

In the developed world there is increasingly a different situation which is much broader than seed technology – a problem with attracting students into agriculture or related areas. With increasingly

[1] This list is indicative only; within each region there are other universities which offer postgraduate qualifications in seed technology.

urbanised populations, where the knowledge of agriculture is limited to the "fact" that milk comes from a bottle and chicken from a plastic tray at the supermarket, a career in the land-based industries is not seen as an attractive option. In a speech to secondary school careers advisors in 2008, New Zealand's then Minister of Agriculture, the Hon. Jim Anderton stated "in the past three years, as a proportion of New Zealand's total graduates, those in the agriculture/agribusiness areas comprised only 0.01% (c.f. 25% in the society and culture category, and 8% in the creative and performing arts). The Minister went on to say "these percentages are somewhat back to front, because we need many, many more people to meet the demand from the primary industries". New Zealand is not alone with this problem; similar situations exist in Australia (K. Boyce, pers. comm., 2009) and Europe and North America (M. Bruins, pers. comm., 2009).

Generation Y

In the agricultural world of today, the drivers and leaders have been the baby boomers (born between 1946 and1964), who are now starting to retire. The average age of farmers, scientists and agricultural industry personnel is approaching 50 years in many countries, and it would seem that Generation X-ers (born between 1965 and 1979) tended to view a career in agriculture as unattractive. As the baby boomers retire, attracting vibrant, energetic, passionate, motivated, creative and able young people as replacements will be vital for agriculture, including the seed industry. Members of the Y Generation (born between 1980 and 1995) fit this description – by their own admission (Rowarth and Goldblatt, 2006).

Much has been written about the Y generation (e.g. Sheahan, 2005; Heath, 2006). Some characteristics (Rowarth and Morris, 2008) of them are:

- preferred style of leadership – collaboration with management is expected;
- value of experience – irrelevant as the world is changing so fast;
- autonomy – questions, questions, questions;
- feedback – needed constantly and immediately;
- rewards – money talks;
- training – still in exam driven mentality;
- work hours – as long as needed (or until they get bored);
- work/life balance – busy lives; need a lot of "me" time;
- loyalty – already working out their exit strategy;
- meaning of money – just something that allows them to maintain their lifestyle.

Note that these characteristics were compiled before the current world financial crisis; 2009's reality may result in some changes, particularly the rapidity with which they expect to change employment!

It may appear that I have digressed too far from my topic of today, but for the seed industry, it will be members of Generation Y who replace the baby boomers. While it is easy to over-generalise, it is significant that the Generation Y-ers want personal career development, and are used to the concept of a mentor (Rowarth and Goldblatt, 2006).

Capacity in Seed Testing

In 1974 when I began my career in seed technology at what was then the New Zealand Official Seed Testing Station, 86 seed analysts were employed in the laboratories. "Seed analyst" was an occupational class within the public service and therefore had its own salary scale. Each year up to 20 school leavers were taken on, and after three years of practical and theory training (including passing examinations), became qualified as seed analysts. Although the New Zealand seed industry of that time was considerably smaller than that of today, taxpayer dollars paid for all seed testing and as a result, each seed lot was tested approximately every three months!

Times change; within ISTA's membership today there are:

1. Seed testing laboratories which remain part of a government organisation and receive varying amounts of taxpayer support (e.g. much of Eastern Europe).
2. Laboratories which are still designated as "governmental" but receive no taxpayer support and must be financially self-sustaining (e.g. Denmark, Netherlands).
3. Private independent laboratories operating as a commercial business (e.g. Australia, US).
4. Seed company laboratories testing proprietary seed lots (e.g. Denmark, Hungary).

The days of any laboratory employing large numbers of seed analysts have also largely disappeared. In a 2009 survey of ISTA member laboratories:

- The mean number of analysts employed per laboratory was 11.4, with a range from 1 to 26.
- Only 9% of the laboratories employed more than 20 seed analysts
- 19% of the laboratories employed five staff or less
- For 54% of the laboratories, up to half of their analysts were employed on a part-time basis.

Factors effecting this change include:

1. A reduction in seed lot numbers for testing, either because of changed seed production practices (e.g. fewer, larger fields), or increases in seed lot size following changes to the ISTA Rules (e.g. from 20t to 30t for cereals).
2. Commercial reality following loss of taxpayer funding. A requirement to be either cost neutral or make a profit on the year's activities means that staff numbers are examined critically. The seed-testing business is "lumpy" in that the greatest demand for testing normally occurs in the five months following harvest; the use of part-timers during this period can be cost-effective.
3. Competition for the seed-testing business has reduced demand for services for laboratories which might have previously enjoyed a monopoly.

Seed Analysts

The international trading of seed relies on the skills of the seed analyst. Seed industry confidence in the accuracy of the seed lot quality information presented on an ISTA International Seed Analysis Certificate derives from the fact that the certificate was issued by a laboratory accredited to do so by ISTA. The gaining of that accreditation, and the laboratory's ability to retain that accreditation, ultimately depend on the expertise of the seed analysts employed.

A seed analyst requires a basic knowledge of seed biology and seed physiology, must be able to identify seeds of several 100 crop and weed species, distinguish between normal and abnormal seedlings, understand the importance of seed sampling and accurately conduct seed quality tests. Some specialise in a small number of agricultural or tree/shrub species, while others deal annually with many agricultural, horticultural and amenity species. Some only test temperate species, others mainly subtropical and tropical species, while yet others test species from within all these groups. A seed analyst is therefore required to be a highly trained specialist.

Are there currently sufficient qualified seed analysts to meet demand? In the only recent survey which asked that specific question, the response from North America (Anon, 2006) was that AOSA/SCST members considered there was a shortage of seed analysts. In Australia and Asia, recent seed analyst vacancies have been difficult to fill (K. Hill, pers. comm., 2009); note that while there is usually a reasonable number of applicants, few if any have any seed testing experience. The situation is also similar in Europe, where most applicants have little or no previous seed testing experience (J. Léchappe, pers. comm. 2009). In the 2009 ISTA survey already referred to, only 16% of the seed analysts currently employed by ISTA member laboratories had previous seed testing experience prior to that employment.

In the North American survey, respondents suggested the following reasons for the shortage of seed analysts (Anon, 2006):

- lack of training opportunities;
- amount of training needed to become a certified/registered seed analyst;
- low salaries do not reflect the amount of training required to become qualified;
- lack of emphasis by school careers' advisors for agricultural careers.

The lack of training opportunities is also a feature for Australasia, Asia, Africa and South America, but is currently less so in Europe. In the majority of ISTA's member countries, the training that is provided is "in-house", meaning that trained analysts do the training. For a large laboratory, work schedules can be more easily organised to provide time for training, but in small laboratories, time required for training can significantly reduce throughput, as a qualified analyst is removed from seed analysis work.

While currently most laboratories have trained staff it is of concern that in many of them, particularly government laboratories, the majority of these staff are either baby boomers or early generation X-ers. They will retire within the next 15 years. In some countries the same applies for the part-time staff who are employed at peak demand times. There are very few of the Y Generation employed as seed analysts, partly because they do not see a career path in seed testing, but also because, at least until this year, there have been more attractive salary packages available elsewhere.

Will new seed-testing methods reduce the need for seed analysts? For some seed quality attributes such as cultivar purity, seed health and the presence or absence of specified traits, there are already highly accurate and rapid testing methods available, but not yet in common use primarily because of cost. New approaches for the "bread and butter" of seed testing, purity and germination, have been proposed, and ISTA has a New Technologies Committee charged with evaluating the potential of these methods for routine use in seed testing. While it is possible that methods may be found which reduce the time required to obtain results, it is unlikely that they will ever fully replace the need for skilled seed analysts.

Maintaining Capacity in the Seed Industry

The seed industry will need to find ways to not only maintain the present capacity in seed technology and seed testing, but to increase that capacity. Generation Y-ers must be attracted into the industry.

Seed Technologists

Convincing young people that there are interesting and rewarding career opportunities in agriculture, and specifically the seed industry, is not an easy task, and the approaches necessary may differ among countries. In countries such as Brazil, China, India and Iran which have seed technology departments at one or more universities, graduates are available to fill positions in the seed industry. In developing economies where there appears to be a great interest among young people, providing scholarships for individuals to pursue a tertiary qualification in seed technology is an option. Traditional sources of such funding, for example Western government overseas assistance programs, have either ceased or substantially diminished, as "seeds" have been downgraded in priority or removed completely from target areas. In the 1980s, the Western governments provided scholarships for students from Africa, Asia and the Pacific to come to a university in the US, UK or New Zealand and study seed technology (Hill and Coolbear, 2005); today funding is no longer available for this purpose. It is now time for the regional seed associations in Asia/Pacific and Africa, in conjunction with FAO to assess priorities and organise scholarship funding from whatever sources are available (with the important proviso that students must return home after graduating and work in the local seed industry!).

In the developed economies, some large seed companies (e.g. Monsanto in the US) do provide scholarship funding to universities, but this alone may not be enough. Generation Y-ers are familiar with mentoring (Rowarth and Goldblatt, 2006). Consideration should be given to identifying promising recruits early and while providing fees bursaries/scholarships, also provide vacation and academically credit-bearing internships as a way of gaining work experience and eventually a position with the company. The New Zealand dairy industry has adopted this approach with some success; from the first year, selected university students are supported financially, mentored, provided with vacation employment and know where they will be employed and at what salary after they have completed their degree.

While this approach has much to commend it, there is still a problem in that it only captures young people who have already decided on a career in primary industry (as indicated by the degree for which they have enrolled). It is not directly targeting those who have not previously considered there could be a career in the primary industries for them. As Rowarth and Morris (2007) observed, "Meeting the needs of the future requires proactive management by industry and education providers together. It needs to be directed by creative and exciting vision for the future, and inform them that there is more to these industries than just 'farming'. It must create a new perception of what a future in the primary industry has to offer". For the seed industry, this is a challenge which can best be collectively met by ISF, the regional seed associations and national seed organisations. The seed industry is ultimately dependent on the maintenance of the technologies which currently serve them and the development of new technologies. The private sector must take responsibility for its own future by adding investment in people to the investments already made for infrastructure and research and development.

Seed Analysts

Attracting young people into a career in seed testing and retaining them is probably more difficult than attracting them into a career in seed technology, primarily because the career options for the former are not as attractive as for the latter. Increasingly seed analysis is regarded as a basically unskilled job, and training on the job is not attractive. Additionally, a seed-testing business does not generally have the capacity to offer salaries for qualified staff as high as those that could be obtained in other occupations after the same time of training (i.e. up to three years). In most countries, seed analysts are not highly educated, but interestingly there are some laboratories in Asia and Africa where prospective seed analysts must hold a BSc/BAgrSc or higher degree before they can gain employment.

It is evident that many laboratories will require new staff within the next decade; the smaller laboratories in particular would like to employ trained staff, but increasingly this is not an option. For them, having to train beginners is difficult because of the time away from seed testing required. Other laboratories may continue to meet their needs by providing in-house training.

One method to attract new seed analysts and allow them to develop and meet career aspirations may be to introduce some form of international seed analyst training, based on the ISTA Rules for Seed Testing, with a program that culminates in an end-point (e.g. a Certificate or Diploma in Seed Testing) that is recognised internationally and would allow the holder to move among laboratories within a country or between countries. The latter is already occurring; seed analysts from an ISTA laboratory in the Netherlands travel to an ISTA laboratory in New Zealand and assist with testing at the peak of the season, and vice-versa (while innovative, it is successful only because the seed-testing peaks occur at different times of the year, and staff from both laboratories are willing to work in another country for several months each year – it does not address the long-term shortage of seed analysts).

Another method may be to make the job of a seed analyst more attractive, because the work involves a lot of routine tasks. Seed analyst job satisfaction is generally greater in a small laboratory than in a larger laboratory, because in the former, the analyst is likely to be conducting different tests on different species, while in the latter, the analyst may be conducting the same test five days a week. As noted by Dr Anne Bülow-Olslen, who as an auditor has visited seed laboratories all around the world: "In my opinion, making the job of an analyst attractive must be based on a varied job (not just barley purity tests from morning to evening), and ideally access to modern technology rather than only manual tests".

As already mentioned, ISTA is currently working with its member laboratories to address their needs for seed analyst training. Whether this alone will be sufficient to attract new seed analysts into the industry is doubtful.

Conclusion

Since the 1980s in the developed world there has been a gradual shift in responsibility for seed industry and seed quality assurance matters, moving from direct government support to increased private inputs. This is likely to continue elsewhere in the world. It is time now for the private sector to take responsibility for their own long-term survival; continuing to rely on governments may cease to be an option.

What will happen if the last highly skilled seed analyst goes the way of the dodo? A seed quality test result is only as good as the analyst. Will crops fail and people die of famine because the seed sown was not tested accurately? Will quarantine weeds rapidly multiply in a new country because their seeds were not recognised during a purity test? Will a seed-borne disease reduce yields and quality because the pathogen was not detected in the seed lot? "Over-the-top" scenarios, or are they?

Like other primary industry sectors, the seed industry is already experiencing difficulties in attracting Generation Y-ers to replace the retiring baby boomers. Motivators for Generation Y employees have been identified as culture, team, management style, flexibility, conditions and salary (Sheahan, 2005). The challenge for the seed industry is to create a workplace environment that acts as a magnet for talent. The message to young people must be that the seed industry offers a vibrant career with a myriad of opportunities. The time to begin is now.

Acknowledgements

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References

Anonymous (2006). Industry needs Trained Seed Analysts. Seed Testing International 131:48.

Bruins, M. (2008). The International Seed Trade and the Difference in the use of GMO Seeds – Challenges and Consequences. Presentation to ISTA Seminar on Specified Trait Testing, June 16, 2008, Bologna, Italy (unpublished).

Chin, H.F. (1991). Man and Seeds. Universiti Pertanian Malaysia, Serdang, Malaysia. 32pp.

Copeland, L.O., McDonald, M.B. (1995). Seed Science and Technology (3rd ed.). Chapman and Hall, New York.

Dominguez, C.E., Peske, S.T., Villela, F.A., Baudet, L. (2001). Informal Seed System: Causes, Consequences and Alternatives. Universidade Federal de Pelotas, Pelotas, Brazil. 190pp.

Evanari, M. (1984). Seed Physiology: its History from Antiquity to the Beginning of the 20th Century. The Botanical Review 50, 119-142.

Feistritzer, W.P. (1975). The Role of Seed Technology for Agricultural Development. Seed Science and Technology 3, 415-420.

Gerard, G. (2008). Notes for talk to students, Lincoln University, New Zealand (unpublished).

Hampton, J.G. (2002). What is Seed Quality? Seed Science and Technology 30, 1-10.

Heath, R. (2006). Please Just F* Off It's our Turn Now. Pluto Press, London.

Hill, M.J., Coolbear, P. (2005). Development of Education and Training in Seed Science and Technology. Seed Science and Technology 33, 1-9.

Le Buanec, B. (2007). Evolution of the Seed Industry during the Past Three Decades. Seed Testing International 134, 6-10.

Rowarth, J.S. Goldblatt, V. (2006). Science as the Career of Choice for the Y Generation. New Zealand Science Review 63(2), 39-43.

Rowarth, J.S., Morriss, S. (2008). Human Capability: Recruitment and Retention in the Agriculture and Life Sciences. Report prepared for the Massey and Lincoln University Partnership for Excellence, Palmerston North, New Zealand (unpublished).

Sheahan, P. (2005). Generation Y: Thriving and Surviving with Generation Y at Work. Hardie Grant Books, South Yarra, Australia.

Steiner, A.M., Kruse, M. (2007). Nobbe's Statute concerning the Testing of Agricultural Seeds of August 1869. Seed Testing International 134, 11-13.

Discussion

FRANÇOIS BURGAUD: François Burgaud from French Seed Organisation. Two small remarks. First, you have no possibility to do that because of time, but we always have to think that when we are talking about developing countries, there is, as you know, a very different situation in Asia, Africa and Latin America. The second thing, to talk about Africa, my feeling and my experience is that what we miss more is not post-graduate persons in seed business, but - if I may say that - undergraduate persons. You know, people who are going only to college, but in the college who have some specialisation, and not only for laboratories, but it is also the case for the production of seeds and everything about seeds. And it is one of the main problems, to have this type of education, organised by the governments. It was when we had the privatization in Morocco for example it was really the biggest problem to find that type of persons. The second thing is more general and we will discuss that, I think, this afternoon. I think the idea of accreditation of private laboratories of ISTA is a good idea to have more flexibility with the national responsibilities of governments, if we go also on this way on OECD. Until it is not possible to have OECD accreditation of the seed company alone, without government, I think it is impossible to use fully the ISTA accreditation. And finally, you can't think that a regional association will do a lot of work to implement that in the situation of today. The main problem of a regional association in developing countries is to find ways to encourage production of seeds. And until you have production of seeds, you don't really need somebody very good to analyse anything.

JOHN HAMPTON: Thank you for your comments. I fully agree about the need to have skilled people in all aspects of the industry, and if I could just give the example of the Massey University Seed Center at which I was working. In 10 years we had nearly 900 people through that center, with training from short courses though to post-graduate qualifications. The original idea always was going to be that these were the people who were going to be training the trainers. We surveyed people who had returned home to find out five years later where they were working. Nearly 60% were not involved with seeds whatsoever. And as Michael already referred, I think that is being one of the big problems; that people who did have the training and gained the skills - and these were not all seed analysts, these were production, the whole game of seed technology - simply moved off to other areas.

ORLANDO DE PONTI: I found it a very interesting presentation, thank you. Especially because you are right, and that is an overall problem of the seed industry, that we are facing the retirement of the baby boomers and this situation is taken very seriously by the companies, because of course they need competent people as successors. In one of your slides, you called on ISF to take collective responsibility. I think there is a different perspective what we have. We all are very much aware of the problem and it is taken very seriously by national seed associations. The big national seed associations all have programmes on training and in the end I think it is the individual responsibility of the individual companies; but they have joint programmes quite often in a particular country. The first important point is, as you mentioned, you have to bring those people into the company. Because as soon as you are in a company and want to make a career, the companies are very interested to give them all kinds of trainings. And it is in-company training but quite often it is a combination with government or semi-government organizations. Just to give the example for seed analysts in the Netherlands; that is a joint programme, it is very well covered by Naktuinbouw. And the companies are very happy to bring their good people to those trainings and of course the companies will pay for the training. So, again, it is working together in order to build the capacity, to maintain the capacity. The problem is, the most important problem is to attract the attention for the industry. You say, it is a vibrant industry and of course I agree it is a very vibrant industry, but the problem is to raise the interest of the school kids to take up a career in agriculture. Because, whether we like it or not, agriculture is not sexy – that's the problem. They move to other fields of career etc, and again we take our responsibility. We have all kind of programmes and we have spent a lot of budgets to attract them to our industry. And they can become a plant breeder, a seed analyst, a seed sales person, whatever. But this is just taken extremely seriously, but I can also tell you it is not easy. It is more about psychology than about genetics.

General Discussion

KATALIN ERTSEY: I would like first to return to the other question raised at the beginning by the European Union representative which was regarding the seed moisture content and also the correlation between the moisture content and the seed quality and how to handle it. And I would like to ask Alison to answer this question. And of course after that the floor is yours for free discussion.

ALISON POWELL: I think the suggestion was that there could be a linear relationship between a reduction in seed moisture content and improved germination and vigour. I don't think you can say that. Seed moisture content is important in terms of influencing the response of the seed to subsequent storage, and there it is true that in orthodox seeds, the reduction in seed moisture content will improve the storage potential. So you compare the storage of a high-moisture content and a low-moisture content seed after a period of time – yes, below-moisture content seed will have higher germination and vigour, but that is only after a storage period. If you were to take two seed lots grown in the same area, reduce the moisture content at harvest of one much lower than another, I doubt there would be any difference in germination and vigour at that time. It might be, if there is a very big difference in moisture content, that the high-moisture content seed would germinate a little faster, but that would just be on the basis of it having a higher moisture at the beginning of the germination phase, rather than its intrinsic germination or vigour capacity. So I think the main effect of moisture content on seed quality is through its influence on storage potential.

JOHN HAMPTON: If I could just add to that comment on this, the other side of the coin, where seed moisture content in fact gets too low, and you are likely to be in a situation fulfilled saying where there is plenty of moisture you are likely to get imbibition damage because of the very rapid uptake of water, and so that again would in fact decrease performance, even though potentially it was a high vigour seed lot.

EUNICE OMBACHI: Thank you. My name is Eunice Ombachi from Kenya. I would just like to know whether there is a really serious effect on the method of drying seed after harvesting and maybe does it matter what the speed is and the time of drying, and what is the long-term effect on the quality of seed?

ALISON POWELL: I think the speed of drying and its effect on quality will largely depend on the initial moisture content of the seed, because if you are starting to dry a seed with very high moisture content and you dry that rapidly, that could be damaging. And of course very high temperatures during drying, particularly when the seed starts at a high moisture content will be damaging to the seed.

ROBERT GUEI: My name is Robert Guei from FAO. I would have two comments. One is a general comment, and then the other one will be to address some of the concerns that were raised during Larinde's presentation. The first one is: there is one aspect, which for me was not really dealt with during the presentations and for me is important maybe will be addressed later on. When we look at the title of the Conference, it is "Responding to the Challenges of a Changing World", and one of the global challenges that we are facing today is climate change. Some people don't believe in that, others do, but the fact is that today in West Africa, floods are happening there today which have destroyed most of the seed capitals have not happened before for a long time. In East Africa there is draught. We trust that it is developing fast. Yesterday in the news they were talking about hurricanes or tornados in Southern, let's say Latin, America, which was not there before, with very, very bad effects. So the problem is, there was a presentation on breeding and although breeding actually contributes to climate change adaptation, in most of the developing countries where the seed sector or the seed system does not exist or is not efficient, it is difficult under these conditions for farmers to have access to the good varieties that the breeding would actually come with. So for us, investing, encouraging policymakers to invest in the seed system development enabling policies for the private sector, IP issues that we talk about, those things actually I am quoting for the private sector to operate in these countries, so that we can have an efficient seed system to contribute rapidly to having access to these good varieties. And I think this is important. It is so important that also at the beginning of the Conference paper they say that this event is aimed at policymakers and government officials. So for us, FAO, what we get out of this, what we have to take to these policymakers will be to appraise them to invest and unless this Conference actually appraise that, it will be difficult for us to do. So my suggestion is that this should be actually recognised by the Conference.

The second issue is the QDS issue, the question that was asked or the concern about QDS. And I would like to say, to add to Larinde's response, that QDS is only a minimum standard for countries that don't have any other standard in place. It is not used actually in Europe, because European they have standards in place, but in some African countries where the seed system is strong or really where they have standards, they are not required to use QDS. So it is only in countries where such standards do not exist, and it has actually been very helpful for some of the crops in those countries where no standard exists. Thank you, Madam Chair.

KATALIN ERTSEY: Thank you for these remarks and I hope our Conference can also add some things to solve these problems. Mr. Le Buanec, please.

BERNARD LE BUANEC: Thank you Madam Chair. Le Buanec, Bernard, Organising Committee. First reaction on what Mr. Guei said; of course we will have the conclusions of the Conference tomorrow evening, so we will be able to check what we are going to say tomorrow evening, but it won't be far from what is said now I guess. I would like to come back to the question from our colleague this morning on insurance. And that is a very tricky issue. And you say, Madam Chair, that of course it is easier to have an insurance when you have quality assurance, and I agree. But then insurance, who do you want to insure? The farmer, if he has bad seed; the seed producer, the seed seller, the seed company in general? If it is the farmer it is always difficult, because when there was a problem in the field, the farmer first of all always says: "we have bad seeds". But then we have to show that it is really the case. So you need experts to be sure that it is bad seed or not. Then you have to know if you have standards and then of course if it is fraud, it is clear, according to the country it can be a criminal act, but that's a legal issue, that is not a question of insurance - it's a legal issue with penalties. And then you have errors and omissions and here you have a lot of insurance systems that have been put in place by insurance companies. So it is a very tricky issue and if ISTA wants to embark on it, I would really encourage them to be extremely careful and take a lot of lawyers to help them. Thank you, Madam Chair.

FRANCISCO MITI: Thank you. My name is Francisco Miti from the Seed Control and Certification Institute in Zambia. I have two questions. One to Larinde and the other to van der Burg. Larinde in his presentation he said national system for limited generation of seed production. I really did not understand what he meant and wanted more clarification on this. The presentation of van der Burg was quite exciting and particularly the area of ethanol production by seed that is deteriorating. From Ms. Powell's presentation this morning we know that germination can be high when vigour in fact is low, meaning that seed deterioration has already started when in fact the seeds have good germination. It means at this stage that ethanol production should have also started being generated, because the seeds are deteriorating, according to van der Burg. I see this test to be very useful especially in the area of measuring vigour, levels of vigour, seed vigour. Probably I missed some statistics, but if he has I wanted some statistics about the correlation of ethanol production to vigour. Are they positive, is it a strong correlation which people can depend on so that they can interchange and use it for vigour determination? Thank you.

MICHAEL LARINDE: Thank you, Madam Chair. Basically I am talking of a seed certification system, because in seed certification you limit the generation; you go from one generation to another till you get to certified seed, and it could be classical seed certification or, in this case, Quality Declared Seed. Thank you.

JOOST VAN DER BURG: Thank you for the question, Mr. Miti. Ethanol production is a very new item for us at least, and my colleague Steven Groot can give you all the details, so I will be happy to provide you with his e-mail address. So far we have been experimenting with Brassica seeds only, so it is only available for that species until now and I made the graphs a little bit nicer, but the sketches were there underneath but I cannot show them right now. I will be happy to provide you with them later on.

ALISON POWELL: As I know well that ethanol has been related to vigour for many years. It was related to vigour first of all in India, in Calcutta by Professor Bhasu (?) and he himself actually developed some vigour tests. This new method obviously offers a lot of potential for rapid detection of differences in seed vigour, but like the colleague from Zambia I am also looking forward to see the correlations between the evolution of ethanol and either field emergence or storage potential of seed lots. Only where assessments are related to an outcome of vigour, do they really test seed vigour. So I am looking forward to seeing that data.

OBONGO NYACHAE: Thank you. I wish to clarify the situation of seed in East Africa. A lot of work has been going on in harmonising regulations, seed rules and laws in 10 countries in Eastern and Central Africa. And several of these have actually developed legislation that supports a formal seed system. And some of the countries have even applied in order to be accredited by ISTA, by OECD in order to have these systems supported by their own governments. SADC, the Southern African Development Coordination, also has a programme, I think you will hear it later in the afternoon, where a lot of effort has been made to try and bring people out of these informal, perpetual system of poverty. So I am really making an appeal. Robert, you did explain that the Quality Declared Seed Systems are in the countries which do not have capacity. That is OK. Where those countries have moved a step and have legal mechanisms for the development of the seed sector in their countries, my appeal is to put money in the systems that are existing that support finally a more sustainable seed system. I have in mind a country like Uganda. Ten years ago they did not have such a system. Now they have more than 20 companies that have invested in the development of seed. That is true of several countries I could quote here. So in such countries it is very important that they get supported, the private sector gets supported, to be able to pick up seed development, including the so-called orphan crops.

VICTORIA HENSON-APOLLONIO: Thank you. I am Victoria Henson-Apollonio, I work with CG Systems, I head up the Central Advisory Service on Intellectual Property. I found this morning's presentations very, very fascinating, because I think it is really important for our CG stakeholders, our poor farmers, resource-poor farmers, that they have quality seed that they plant. And I am curious; you know yesterday we heard a lot about patent protection and PVP, but I am wondering about translating all of the work that you all have been talking about this morning into something that the customer can recognise, the farmer can recognise, as being seed that is quality seed. So I wanted to sort of raise the flag a little bit about trademarks, but I am curious what is the thinking of ISTA about making farmers aware that they can trust this seed. I hear a lot of programmes that are on the other side in terms of developing quality seed, but I do not hear anything about the side of the farmer or the customer in terms of knowing about what this means to them.

KATALIN ERTSEY: I would like to answer very short. I think the work of ISTA and all that we have done is only a tool to achieve the goal of using quality seeds. We have 74 member states and I think so the ISTA member states, inside the country and the ISTA members inside the country, they have the task to do it. And me personally and I think all our colleagues try to do it in their countries' interest to keep this message to the farmers and the growers.

KATALIN ERTSEY (SESSION SUMMERY): I think that this session has demonstrated that seed is the first determinant of future plant development, and the quality of the seed used is the starting point and one of the most important factors for successful plant production. The first presentation underlined the different testing methods that are available to help to fulfill the requirements of farmers and growers. The determination of seed quality parameters, of course, needs broad knowledge on taxonomy, botany, seed physiology, biology, seed processing and also some legal knowledge, and demands intensive scientific study or work.

In the second presentation, our speaker analysed the correlation between quality of seed used for cultivation and agricultural yield, and supported the establishment of a quality assurance system and certification schemes as a good means to achieve good seed quality.

And I think the outcome of the third presentation was the same: the evolution of seed testing. It is clear from this presentation that secure seed supply systems are needed all over the world with uniform application of methods for seed sampling and testing and that we require well-equipped laboratories with pertinent quality assurance systems and staff with the necessary knowledge and skills. I think the ISTA Rules and the ISTA Quality Assurance System can fulfill these requirements.

From the FAO presentation, for me, it seems that there are huge security problems in the world, and also seed security problems too. I think we have to be aware of this. And also underline that in many countries quality seed is simply not available to poor farmers, either because they cannot afford it or because they do not have ready access to supply.

From the fifth presentation our speaker assured us that there is permanent progress and development to evaluate seed technology and use of it for better seed quality determination and these technical procedures are based on the latest scientific research.

And now I come back to the presentation about the necessity for the seed analyst. We realised that there is a lack of highly educated seed analysts because of significant cuts in scientific research activities and programmes over the last decades, with reduced possibilities for young academics: and also the use of scientific knowledge as a competitive advantage for companies and the need to make money out of scientific knowledge, the huge transparency and scientific exchange of the latest research results. The uncompetitive salaries for seed analysts in developed countries make the career in seed quality control unattractive for young people. Governments as well as the private sector need to give increasing attention to this development to prevent it having a negative effect on the overall seed sector. And now I would like to close our session only with one sentence: High quality seeds are the basic requirements for productive agriculture.

Session 4. Conclusion, presented by the Chairperson
The importance of quality seed in agriculture

- The session demonstrated the importance of seed quality for crop productivity and agricultural production. It has underlined, that a lack of information on seed quality could result in crop failures and has the potential to threaten food security for whole countries
- The determination of seed quality parameters requires a broad knowledge of plant and seed physiology, taxonomy and botany and requires intensive scientific studies and research
- The application of seed quality evaluations requires a detailed knowledge regarding seed production, seed marketing, seed regulations and the seed sector
- Since 1924 the International Seed Testing Association (ISTA) has been the impartial and objective platform where leading seed technologists and researchers have come together to discuss relevant scientific progress and make the necessary definitions regarding seed quality and how to measure it
- Currently in developing countries there is not an adequate seed quality assurance infrastructure with respect to seed testing and this is required to increase crop productivity and provide enhanced food security in these countries
- The evolution of seed quality determination has not reached an end point and there are interesting developments in the pipeline that take account of the changing needs of the market. These will make tests and their applications more relevant, effective, robust, quicker and cheaper
- Significant cuts in scientific research and education has reduced the possibility for young academics to acquire the necessary seed technology skills
- In the seed technology area transparency in and scientific exchange of the latest research results remain of crucial importance for continued progress
- Uncompetitive salaries for seed analysts in developed countries make a career in seed quality control unattractive for young people.

Session 5

FACILITATION OF TRADE AND MARKET DEVELOPMENT

Chairperson: Mr. JOHN C. KEDERA, Managing Director, Kenya Plant Health Inspectorate Service (KEPHIS) (Kenya)

- **Overview of the regulatory framework in seed trade**
  Mr. JOSEPH CORTES, Seed Science Center, Iowa State University (United States of America)

- **The role of international certification in facilitating trade and market developments**
  Mr. MICHAEL RYAN, Head, OECD Codes and Schemes, Directorate for Trade and Agriculture, OECD

- **Phytosanitary measures and the international seed trade**
  Mr. JEFFREY JONES, Senior Officer (Phytosanitary Capacity Building), International Plant Protection Convention (IPPC), Plant Production and Protection Division (AGP), Agriculture andConsumer Protection Department, FAO

- **Harmonization of seed testing for the facilitation of trade**
  Mr. JOËL LÉCHAPPÉ, Director, National Seed Testing Station (SNES) (France)

- **Harmonization of the seed regulatory framework at the regional level**
  Mrs. PAIVI MANNERKORPI, Head of Section, Unit for Biotechnology and Plant Health, DG Health and Consumers, European Commission

General discussion

Conclusion, presented by the Chairperson

OVERVIEW OF THE REGULATORY FRAMEWORK IN SEED TRADE

Mr. JOSEPH CORTES*

My presentation will be divided into three parts. The first part will be an overview of the regulatory framework of seed trade from an international perspective. The second part will look at these regulatory frameworks from a regional perspective and, finally, we look at whether this makes any difference.

The seed science centre at Iowa State University took a decision about 10 years ago to work in the area of seed policy regulations, laws and harmonization to facilitate seed trade. It was a conscious decision and an effort to do something that would have a global meaning, so we stopped doing a lot of things that we had been doing at national level. We looked at it from the standpoint that world seed exports are very important,. but there is a secondary importance that sometimes people tend to forget: every pound, every kilo of seed that is sold means that farmers somewhere in the world are getting improved varieties from high-quality seed.

When we look at seed trade, we also look at it from that perspective. It is something that we must do if we want to change some of the regions of the world in terms of how much they are producing and how well they produce.

In terms of the international regulation of seed trade, you all know there are the seed certification schemes, the seed testing areas, the phytosanitary measures and plant variety protection. Those are the four main pillars on which our international regulatory frameworks rest. Let's look at seed certification. We have two systems in the world: OECD with 57 country members which is a mandatory/compulsory system, and the one that exists in AOSCA which is a non-compulsory and non-mandatory system. You might ask which one is better; I would rather give the private sector the opportunity to answer that question. They are each probably comfortable with the systems they have, and there is really nothing better.

If we look at seed testing, it is ISTA that applies its rules around the world; there are 182 laboratories in 74 different countries. However, there are many countries that are not ISTA members, that are not OECD members, that are not AOSCA members, so we need to work closely with them to make sure that they also come into the system of the international schemes.

In terms of plant variety protection, UPOV is the one that is most recognized, or even the only one that is recognized and currently it has 67 country members.

In terms of the phytosanitary measures of the IPPC, I will not go into the details since we will have presentations on these measures from the IPPC and also from the national plant food sector organizations.

Regarding regional harmonization of seed regulatory frameworks to facilitative trade, 10 years ago Iowa State University started doing work on this in Central America. First, what we tried to do was identify those things that were a constraint to the trade. This is of course relevant when you have a regional variety release system. Then it seems that seed companies will have fewer costs, both in human resources and in time to release a variety from country to country. Thus you really have much to gain as you look at regional variety release systems as is the case in the EU. In terms of seed certification and accreditation, we work in trying to harmonize the standards of countries, in whatever the area might be. That means field and seed standards and one of the things that is common to our workshops and training sessions is that we make sure that OECD and AOSCA standards are met. We also encourage standards for the region to be a little bit tighter than the OECD or AOSCA standards.

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This is done in order to allow OECD or AOSCA accession by these countries at the time they wish to join. With ISTA, it's exactly the same thing. We insist they follow ISTA procedures, and eventually countries become ISTA members, or at least that is the expectation. Plant variety protection: we have already had a full session in regards to this so I do not need to tell you why it's so important. But we do work with countries in terms of developing plant variety protection and we do this in close relationship with UPOV. We also work very closely with ISTA as well as establishing new relationships with OECD. So for all of these things, we take into account that the private sector needs to be present. We have worked with the Asian Pacific Seed Trade Association, we have worked with the Latin American Seed Federation and the African Seed Trade Association, and shortly we will begin a relationship with the Seed Association of the Americas on a very specific project. So we always do our best to make sure there is private sector representation. You probably have heard several comments that have been made here today with regard to taking the private sector more into consideration when you are looking at the development of seed systems around the world. I totally agree. There needs to be participation from the private sector so that we can grow together; it has to be a partnership between the public and private sectors.

Finally, phytosanitary measures: the things we do in this area concern producing a quarantined pest list based on science. Thus in my presentation you will see what I mean by "based on science", and how there has been a reduction in the number of quarantined pests we have to deal with.

The other thing that is important with phytosanitary measures, and it is common to the rest of the work that we have done around the world, concerns difficulties some countries have to get a phytosanitary certificate, and how hard it is to get a seed export and import certificate. All of these things demand time and effort and people from the private sector constantly complain about this. We have also worked and continue working with countries to develop what we call seed import and export procedures and many of them already have manuals that are in the process of being implemented.

Let's look at the regional variety release systems in, for example, Central America. These have been approved and have been used for five different crops. Within the expanded Mercosur countries (the Mercosur countries plus Chile and Bolivia) there is technical agreement for five crops. The way the system works there is that you can accept data from the private sector. But most important is that you can test in one country, say Uruguay, but Uruguay will accept a year of testing from Brazil, and then you can apply for release, which would be a regional release. A similar system applies to Central America. In the East African community, there is an approved common catalogue, my only criticism being that it is only a catalogue because it is only a total of the different varieties that are released in the three different countries; it's not a common variety release system, but they do have a common catalogue. In the SADC countries, in the southern part of Africa, this involves 14 countries which approved a common variety release system in June of this year. This agreement will be signed in the coming days. There is a presidents' meeting of the SADC member countries in DRC as we speak so it's supposed to be signed by the end of this week. This measure has had the financial support of both USAID and the Swiss Agency for Development and Cooperation; it has been a joint cooperation between the two.

In ECOWAS, action was spearheaded by FAO and they have a common variety release system that was approved last year. This one is a little bit different in that in the 17 countries, if you release a variety in one country, you can market it in all 17 countries. However the system in SADC is that you need to release in two countries to be able to market it in all 14 countries. So it's a little bit different, but with the same common goal of getting more varieties released more quickly into the system.

Central America does have common seed certification standards as does expanded Mercosur and the Andean Pact. In addition to that, expanded Mercosur has seed certification accreditation in place and, obviously, seed testing using ISTA rules. The accreditation part relates to the fact that a person, laboratory or seed company can become accredited to conduct their own quality control on behalf of the government, under its supervision. They audit every year or two, whenever the government decides an audit should be done. I would emphase here in regard to the Andean Pact, that a technical agreement was reached in all cases, except those in the Andean pact, because of the political differences between the countries and CAN, the community of nations, which has to reach agreement by consensus. So all five countries have to agree, and this is not possible at the moment.

In ECOWAS again, action was also spearheaded by FAO, but I forgot to mention that this was also funded by Genus, USAID, and FAO, the three being partners in this particular area of the world. The EAC also has common seed certification standards and they give accreditation for persons and/or entities. SADC works the same way; accreditation is possible; they have common standards and they use ISTA rules. Plant variety protection, which was set up with a lot of assistance from France, is in place. The SADC PVP draft protocol that we worked on very closely with UPOV has eventually resulted in five countries of the region having PVP legislation. They are not members of UPOV – but they will be eventually. The other thing is that as we move forward, there are other organizations that are better positioned than us to continue this effort; ARIPO is a very specific case. We have had very interesting conversations with regards to ARIPO, and I sincerely hope that we can move this forward. For phytosanitary measures, in Central America we have a quarantined pest list based on science and in Mercosur we have the same, plus a seed import and export manual has been developed. In the Andean Pact the pest list, the seed import and export manuals and even phytosanitary accreditation are pending. That means that a seed company that produces different types of crops can apply to do their own seed health testing and their own field inspections for quarantined pests; the same applies to ECOWAS and is still in the process of being developed. This is part of what Iowa State is doing with the ECOWAS countries, as well as assisting with seed import and export manuals. SADC already has both things: a quarantined pest list based on science, and seed import/export manuals.

This system has extended into the countries of the Asia Pacific region which are very interested, particularly because they produce so much vegetable seed. They were interested in having first of all a quarantined pest list based on science. They have also developed their own seed import and export manuals and they have phytosanitary accreditation for the five countries listed there. The only exception for the quarantined pest list is Vietnam. They are still working on that and have to report back to the IPPC. All of these things that we have talked about – do they really make an important difference? First of all, one should look at the quarantined pest list and how it has been reduced. When we started in Central America, there were 82 quarantined pests. The final number of pests that needed to be taken into account for movement of seed within the region was only two; In East Central Africa the figure went from 35 to seven; Mercosur from 50 to 10; Asia Pacific from 158 to 49. In the Andean Pact, 379 pests were analyzed and the number reduced to 112. The only reason you see such a high number there was due to the potato and the cassava; as you all know there are high numbers of viruses associated with these. Finally, SADC was down from 87 to 26. Other things that illustrate whether this is useful in Central America show that after two years of harmonized seed agreement, intra-regional trade has increased by 23 per cent. This is not our data, but data from the Latin American Seed Federation. Can we take credit for the increased intra-regional seed trade in Mercosur? Probably not a lot because there are many things that happened which have influenced the increase of seed trade but we did have something to do with it. For the first time in their history, Paraguay and Bolivia have been able to move seed into Brazil, and Uruguay has considerably reduced complications on moving rice seed into Brazil.

Finally I leave you with this thought. Whatever we do from here on, we need to do it faster; we need to do it better. Let's do it together.

Discussion

MICHAEL LARINDE (FAO): I would just like to fill a gap. The harmonization work in SADEC, including common release of varieties, was also part of FAO activities working with Switzerland. We have a project that has been running for three years.

FIRMIN MIZAMBWA (AGRICULTURAL SEED AGENCY, UNITED REPUBLIC OF TANZANIA): I do agree with you on the benefits of the regional harmonization as well as on the mentioned increase in market size by opening doors where seed can move from one country to another. But I would like to use your experience to highlight any negative impact to this regional harmonization.

JOSEPH CORTES (SEED SCIENCE CENTER): In all honesty, I have not heard of any negative feedback on this. In other words: Has it caused any particular problems anywhere, are there people who might be in disagreement with the approach? I don't know. But personally I have not heard of any negative results because of the harmonization.

GRETCHEN RECTOR (SYNGENTA): I have a question about pest risk assessment and I am wondering if there is any framework for the facilitation of pest risk assessment with your phytosanitary standards.

JOSEPH CORTES (SEED SCIENCE CENTER): No, we do not get into any pest risk assessment. We have left that area to FAO and the IPPC to establish the pest risk assessment. What we did to be able to get to this final list of quarantined pests was to determine if the pest was present or not in the region. If it was not present, then it is not a quarantined pest. If it was already present, of course. Is it seed born? Is it a pathogen that is seed transmitted? No it isn't? Then out you go. And of course the economic value: Is there any economic value that is going to occur in a country because the particular pest is introduced into the country? A couple of times it was seen that it was of such low economic importance that it was left out. Those were the three bases that we used.

FRANCIS OBONGO (SEED TRADE ASSOCIATION OF KENYA): Mr. Cortes was talking about regional lists. I wanted to let the audience know that in East Africa, where this harmonization has been going on for quite some time, we do have a regional list. But there are now legal frameworks, like the seed law in Uganda and Tanzania, and the draft seed bill in Kenya that contain the provisions for regionalization of varieties. Once released in any two countries, they would be eligible to be listed as regional varieties. That has now been provided. Although no applicant has come forward, the legislation is in place.

JOSEPH CORTES (SEED SCIENCE CENTER): Thank you for that clarification. It is not only good for everyone to know, but I am very glad to hear that this is the direction that you have moved into.

JOHN KEDERA (CHAIR): You have raised during your presentation the issue of accreditation. We know in some forums that the term "accreditation" is not used because of what it implies. There is a preference for "authorization". Those are the things you might want to discuss. Regarding the question from Tanzania on regionalization; there has always been a fear that once you apply regional standards, the small domestic companies will be overrun by the bigger ones. And I think that's what he was implying by the matter of years. But we will leave that particular topic.

THE ROLE OF INTERNATIONAL CERTIFICATION IN FACILITATING TRADE AND MARKET DEVELOPMENTS

MICHAEL M. RYAN*

Introduction

The availability of a consistent supply of high-quality seed is the key to a competitive and productive agricultural crop sector. High agricultural productivity is essential to ensuring that adequate supplies of food are provided for the ever-growing world population. The ongoing efforts to develop new plant varieties and the distribution of these varieties to farmers across the globe are of paramount importance.

To ensure that adequate supplies of high-quality seed are available to agricultural producers in both the domestic and foreign markets requires a consistent checking of quality at all stages of the supply chain. The many stakeholders along the seed supply chain including breeders, producers, traders, regulators and farmers work together to ensure that quality standards are maintained and, indeed, enhanced. Close coordination of the work in breeding, testing and certification of seed is critical in facilitating trade of high-quality seed and in lowering non-tariff barriers.

With the advent of new technologies and the growth in demand, especially for hybrid seed, the global seed market has been growing rapidly in recent years. Today, the value of the seed market is estimated at about 37 billion US dollars, of which over 80 per cent is accounted for by North America, Europe and Asia. The global seed trade is dominated by large multinational companies. The international seed trade has grown substantially in recent years and is estimated at 6.4 billion US dollars for 2007. Growth in the international seed trade is being driven by several factors including the rapid decline in transport costs, differential production costs of high-yielding hybrid varieties, better communications and information on the availability of varieties, changing climatic conditions, counter-cyclical production, as well as a more reliable and supportive system of international certification.

In general, the seed trade is one of the most regulated sectors in all countries, with a plethora of seed laws, testing and certification procedures. The simplification and harmonization of testing and certification procedures helps to improve farmers' access to high-quality seed in all regions of the world.

In many countries seed certification is done at both national and international levels. The most widely used global certification systems are the OECD Schemes, while at the regional level other schemes are used, e.g. EU, AOSCA, etc. The main purpose of this paper is to discuss the role of international certification, primarily the OECD system, in facilitating international trade in seed.

The OECD

The Organisation for Economic Co-Operation and Development (OECD) is an intergovernmental Organisation , founded in 1961 and based in Paris. It is composed of 30 Member countries and works with over 70 developing and transitional economies. The Organisation provides a unique forum where governments can compare policy experiences, seek answers to common problems, identify good practices and coordinate domestic and international policies. It is a forum where peer pressure acts as an incentive to improve policy and which produces internationally agreed instruments, decisions and recommendations in areas where multilateral agreements are necessary for countries in a global economy.

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The OECD helps governments to foster prosperity and fight poverty through economic growth, financial stability, trade and investment, technology, innovation, entrepreneurship and development cooperation. Other aims include creating jobs, social equity and achieving effective governance. Analyses provided by the OECD Secretariat help the dialogue and exchange of information between OECD governments. The Secretariat collects data, monitors trends, analyses economic developments and researches evolving patterns in trade, agriculture, environment, technology, taxation, etc.

An Overview of the OECD Seed Certification Schemes

The OECD Seed Schemes provide an international framework for the certification of seed with the aim of facilitating the growth in trade of seed by reducing technical barriers. The Seed Schemes are a globally recognized system for the varietal certification of seed moving through international trade. The Schemes were established in 1958 in response to a combination of factors including the rapidly growing seed trade, the increase in regulatory requirements in some countries, the development of off-season production, the large breeding and production potential of exporting countries in North and South America and demand from the private seed industry.

The purpose of the OECD Seed Schemes is to encourage the use of "quality-guaranteed" seed in participating countries. The Schemes authorize the use of labels and certificates for seed produced and processed for international trade according to agreed principles. The OECD certification is applied to varieties satisfying DUS tests (Distinction, Uniformity and Stability), and the Schemes aim to ensure varietal identity and purity through seed multiplication, processing and labeling.

The OECD Seed Schemes facilitate the import and export of seed by the removal of technical trade barriers using worldwide recognized labels (seed "passport"). They also provide specifications for seed multiplication outside of the country, which is becoming an ever-increasing practice. In 2008, over 500 000 metric tons of seed were OECD-certified, traded and used by farmers. In addition, the main OECD principles can also be applied to seed that is used on the domestic market. In overall terms, the Schemes provide a consistent and operational legal framework at international level.

Trade in seed is subject to bilateral and/or multilateral agreements at local, regional, and international levels. As the first input in the cropping process, high-quality seed brings high genetic yield potential resulting in higher productivity and crop production. The body in charge of seed quality control in most countries is the National Designated Authority (NDA), which has responsibility to ensure the seed meets all the required standards for certification.

The OECD Seed Certification Schemes are based on two key criteria; varietal identity and varietal purity.

- Varietal identity: The identity of a variety is defined by the official description of its characteristics, resulting from a given genotype or combination of genotypes.
- Varietal purity: The purity of a variety is the proportion of plants or seeds within the population that conforms to the official description of the variety.

The Schemes are built on a number of fundamental principles. First, they include only those varieties which are officially recognized as distinct and having an acceptable value in at least one participating country. Second, all the certified seed produced must be related directly through one or more generations to authentic Basic Seed of the variety. In addition, satisfactory conditions for the production and processing of Basic and Certified Seed must be ensured and verified by field inspection and post-control tests. Third, post-control tests are conducted to ascertain that the Schemes are operating satisfactorily.

The number of countries participating in the OECD Seed Schemes continuous to increase with new applicant countries requesting accession on an annual basis. Currently there are 57 countries participating in the OECD Seed Schemes (from Europe, North and South America, Africa, the Middle East, Asia and Oceania), and up to 10 observer organizations also regularly participate in the meetings.

There are seven distinct and independent Seed Schemes and admission to each Scheme is voluntary. The number of countries participating in each Scheme varies with the Grass and Legume Seed, Cereal Seed and Crucifer Seed and other Oil or Fibre Species Seed Schemes the most widely used.

- Grass and Legume Seed Scheme
- Cereal Seed Scheme
- Crucifer and other Oil or Fibre Species Seed
- Maize and Sorghum Seed
- Sugar Beet and Fodder Beet Seed
- Vegetable Seed
- Seed of Subterranean Clover and Similar Species

The success of any international certification scheme depends upon close cooperation between maintainers, seed producers, traders and the NDA in participating countries. The evolution and adaptation of the system depends crucially on the inputs from the NDAs. The frequent meetings between authorities of participating countries allow for the exchange of information, discussion of concerns, the preparation of new Rules and the updating of the Schemes. The NDAs are responsible in Member countries for the implementation of the Schemes.

The European Commission has a special recognized status in the OECD. International organizations, whether governmental or representing industry and farmers, participate as observers in the OECD meetings. UPOV, ISTA and ISF are involved and are very active in the OECD's work. There is long-standing cooperation with FAO and regional organizations such as AOSCA, WANA Seed Network, and also with seed industry networks such as APSA (Asia-Pacific Seed Association), AFSTA (African Seed Trade Association), EESNET (Eastern European Seed Network), ESA (European Seed Association), etc.

Implementation of the Schemes

A number of basic documents are required for the implementation of the Schemes in Member countries including the Rules of the Schemes, List of Varieties and, the Guidelines for Control Plot Tests and Field Inspection of Seed Crops.

The Rules of the Schemes contain all the general and legal texts, standards and technical requirements for each of the seven Schemes, as well as the prescription for certificates and labels. The Rules are discussed and updated regularly in line with the ongoing changes in the regulatory, trade and policy environment.

The OECD List of Varieties eligible for OECD certification includes varieties which are officially recognized as distinct and having an acceptable value at least in one country. It contains most of the internationally traded varieties, the number of which has grown steadily over the last 30 years. The number of listed varieties now exceeds 42,000 varieties and 190 species. In recent years, the largest increase has been for maize and oilseed rape; sunflower, rice, soybean, and forage species. A new updated List of Varieties is published in January and July each year.

In addition to the Rules, the Guidelines for Control Plot Tests and Field Inspection of Seed Crops describe methods that can be used or adapted where local conditions make this necessary, by participating countries.

There are a number of key technical requirements, methods and standards along the seed multiplication chain that all participating countries should adopt in the implementation of the Schemes.

Seed categories: The following categories are recognized, each corresponding to a well-specified generation number and associated technical conditions: Pre-Basic Seed, Basic Seed, and Certified Seed. Each category has its own specific colored label.

Trueness to type (varietal identity): Varieties are maintained true to themselves (to the description of the varieties) throughout successive seed multiplication.

Minimum varietal purity standards: Seed lots must satisfy minimum levels for varietal purity to be preserved. These requirements are achieved by way of previous cropping conditions, isolation distances, etc. Field inspections are made for checking these elements and standards.

Multiplication in another country: Specific provisions allow for the exchange of relevant information. When seed multiplication takes place outside the country of registration of a variety and the NDA has permitted such a commercial multiplication, the maintainer should be consulted and good contact should be established between the NDAs of the countries concerned.

Post-control plots: The identity and varietal purity of the seed is randomly checked each year in official post-control fields set up by the NDA. In some case, chemotaxonomic tests are also used.

Samples and laboratory analysis: Each lot of OECD-certified seed is subject to official laboratory tests (analytical purity, germination, moisture content, etc). OECD Certification uses ISTA or equivalent sampling and testing methods.

Requirements for joining the OECD Seed Schemes

Any country wishing to join the OECD Seed Schemes must follow the procedures as set out in the OECD Rules and should satisfy the following criteria.

- The opportunity to develop exports and/or imports of certified seed.
- A national seed law which provides the legal framework for variety registration and seed certification.
- A national list of varieties.
- An efficient domestic certification system, with adequate equipment and qualified staff for field inspection, seed sampling and labeling.
- An efficient laboratory for seed analysis according to ISTA Rules or equivalent.
- A system of post-controls to check the varietal purity of the certified seed.

Some Recent Developments in the OECD Schemes

The Schemes continue to evolve and develop to meet the challenges of a changing trade, regulatory and policy environment in Member countries, as well as the challenges posed by the participation of new Member countries from different regions of the world. Some of the more recent developments are outlined below:

- India and Moldova became full members of the Schemes in 2009.
- Three new species were recently added to the Schemes: Nicotiana tabaccum, Trifolium spumosumm and Trifolium dasyurum.
- The Netherlands extended its participation to the Vegetable Seed Scheme and Kyrgyzstan to the Grass and Legume Seed Scheme.
- The maximum seed lot size has been revised upwards to 30 metric tons.
- Two technical provisions of the post-control rules were amended in line with the needs of Member countries.
- Other technical amendments related to the revision of the isolation distance for cotton seed.
- The definitions of varietal purity and varietal identity were added to the Rules of the Schemes.
- The Strategic Plan for the Schemes was finalized. The Plan identifies several priority areas for future work within the Schemes. The prioritization exercise will ensure that the Schemes will continue to add value to the work of international certification and will remain highly relevant to the needs of Member countries.

Benefits of International Seed Certification

The harmonization of certification procedures at international level has made a significant contribution to developing the global seed trade. The benefits arising from the facilitation of trade in seeds and the improvement in market access are numerous and can be summarized as follows:

- A lowering of the technical barriers to trade (TBT).
- Improved transparency for traders and stakeholders.
- A reduction in transaction costs.
- The use of worldwide recognized official seed labels and certificates facilitate the exchange of technical information on seed.
- Encourages the development of seed production in other regions and countries.
- Contributes to the elaboration of international rules for seed certification.
- Promotes collaboration between the public and private sectors.
- Shares experiences and information on emerging issues and concerns in the seed sector.

A large number of countries are already participants in the OECD Seed Schemes and this number is likely to increase as more countries are entering international markets, and seed "consumers" are becoming more demanding with respect to supply consistency, quality and safety.

Good cooperation between countries and all stakeholders including international organizations is a response to the need to develop a market-responsive regulatory approach. Every country will continue to be faced with a different legal system and institutional structure and, yet, must compete on the global market.

Conclusions

The rapid growth in the volume of international trade of seeds has given rise to many challenges, not least of which is the need to harmonize certification procedures and to adopt reliable and enforceable standards. The OECD Seed Certification System is the most widely used global certification system for the export and import of high-quality seed.

The ongoing development and release of new plant varieties and the trend toward the multiplication of seed in third countries increase the complexity of the production and distribution systems. Moreover, increasing cooperation between the public and private sectors is paramount to ensuring that the benefits arising from the use of new varieties are shared between the different shareholders in the system

The adoption of international certification standards has encouraged the growth in the seed trade by reducing technical barriers to trade, increasing transparency, lowering transaction costs and increasing access by farmers in all regions of the world to high-quality seed.

Discussion

FRANÇOIS BURGAUD (GNIS, FRANCE): I would like to know if you have already had any discussions at the OECD level, about the possibility of a company in a country which is not in the OECD Schemes, to ask another country to send someone to do the work, so that the company is able to export the seeds. Because in many developing countries, the governments don't want to do the job and pay for joining the OECD Seed Schemes. But in those countries there are some companies with the opportunity to produce seeds especially in counter-seasons. So I would like to know if you might open this door in the future.

MICHAEL RYAN (OECD): This is a question that has been discussed for quite a while in the OECD. There are two parts to the question. One part relates to the multiplication abroad issue, and we have had a technical group working on this issue for some time. Although it's a very complex issue, I think we are making good progress on that. And we hope that the next meeting of our technical working group will be able to report some positive results. The other element you mentioned was related to seed companies working in countries that are not members of the Schemes. As OECD is an intergovernmental organization, we primarily work with the governments of the countries involved in the particular project. However seed companies and a range of other companies are represented in OECD through the BIAC (The Business and Industry Advisory Committee), and some of the seed companies here today are part of that committee. This is a committee that represents industry and they consult regularly with the different OECD committees providing input and advice from the industry. We also have other groupings such as the TUAC and also the IFAP from the farmer's side. The issue of seed going to other countries is also in the process of discussion, but we haven't come to a clear conclusion yet. Once we do come to a conclusion or a consensus on the issue, then there will be a modification in the Schemes. So, these discussions are ongoing but they have not yet come to a conclusive stage.

PATRICK NGWEDIAGI (MINISTRY OF AGRICULTURE, UNITED REPUBLIC OF TANZANIA): In his presentation Mr. Ryan said that one of the conditions for a country to participate or be a member of the Schemes is to have a satisfactory laboratory. I just wanted to know what the conditions for having a satisfactory laboratory are. Whether they are different from what is required by the ISTA quality assurance system and whether you have a separate requirement.

MICHAEL RYAN (OECD): As specified in the rules of the OECD Schemes, it is an ISTA-accredited or equivalent laboratory that is required in terms of the standard.

NARAYAN DHONDI JAMBHALE (INDIAN COUNCIL OF AGRICULTURAL RESEARCH): You said there are 198 species with the 40,000 varieties identified earlier, and then in 2009, 190 species are mentioned and 42,000 varieties. What are the criteria for the selection of these varieties?

MICHAEL RYAN (OECD): The 2009 list of varieties was an update on the earlier one. It is approximate; just over 40,000 varieties. Concerning the addition of new species, the request must be presented to the Annual Meeting of the Schemes. Once approved, the new species are added to the list. For varieties, the criterion is that they must meet a range of descriptive requirements as set out in the Rules and Regulations of the Schemes. These requirements are checked and if, following the check, all the information provided is satisfactory, then the variety is listed on the OECD list. This work is not done within the Secretariat, but it is done by the OECD Coordinating Centre, which at present is NIAB, in Cambridge, UK. They provide the technical input by evaluating the technical content in relation to the criteria for including new varieties on the OECD list.

JOHN KEDERA (CHAIR): We will close the discussion on that. I think there are the two things we need, cost effective regulations and they must be simplified to meet the requirements.

PHYTOSANITARY MEASURES AND THE INTERNATIONAL SEED TRADE

Mr. JEFFREY JONES*

Summary

The international movement of seeds as a commodity for seeds for planting or intended for planting supports food production and hunger alleviation globally. Seeds are considered high-risk material in international trade, providing a ready pathway for movement of pests, especially seed-borne pathogens. The purpose of the International Plant Protection Convention (IPPC) is to prevent the spread and introduction of pests of plants and plant products and to promote appropriate measures for their control. The International Standards for Phytosanitary Measures (ISPMs) published by the IPPC provide guidance regarding phytosanitary measures and their application to the international seed trade.

The Role of the IPPC in Seed Health

The IPPC is a multilateral treaty for international cooperation in plant protection, promoting harmonization of phytosanitary measures in commerce and the environment and is the international phytosanitary standard-setting organization recognized in the World Trade Organization Agreement on the Application of Sanitary and Phytosanitary Measures (WTO-SPS Agreement). Its purpose is to prevent the spread and introduction of pests of plants and plant products, while promoting measures for their control.

The international standards, guidelines and recommendations regarding phytosanitary measures uphold key principles of the SPS Agreement and, for example, encourage Contracting Parties to institute only measures that are:

- technically justified and consistent with the pest risk;
- non-discriminatory: measures applied to imported seeds should be no more stringent than those locally produced and countries with the same phytosanitary status should be treated equally;.
- least restrictive, with minimum impediment to international movement of plants/seeds;
- mindful of equivalence of measures (for a specified risk, different phytosanitary measures to achieve a Contracting Party's appropriate level of protection).

Consistent with the risk-related application of measures, the IPPC has defined pests that should be regulated, namely:

Quarantine Pest (QP): A pest of potential economic importance to the area endangered thereby and not yet present there, or present but not widely distributed and being officially controlled [IPPC, 1997].

Regulated Non-Quarantine Pest (RNQP): A non-quarantine pest whose presence in plants for planting affects the intended use of those plants with an economically unacceptable impact and which is therefore regulated within the territory of the importing Contracting Party [IPPC, 1997].

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Phytosanitary Measures applied to Movement of Seed

A phytosanitary measure is defined as any legislation, regulation or official procedure having the purpose to prevent the introduction and/or spread of quarantine pests, or to limit the economic impact of regulated non-quarantine pests (ISPM No. 5). In that regard, the IPPC has the responsibility to protect plant resources while facilitating safe movement of plants and plant products internationally.

Seeds are defined as a commodity class for seeds for planting or intended for planting and not for consumption or processing (ISPM No. 5). International movement of seeds supports food production and hunger alleviation globally. The importance of the international seed trade takes on greater significance in the face of severe food shortages and higher food prices, deforestation and population increase. Food losses globally due to pests are often estimated at between 25 to 40 per cent (Pimentel, 1997; Oerke and Dehne, 2004) and seeds in international trade provide a ready pathway for movement of pests, especially seed-borne pathogens. Against these odds, the seed industry shares the responsibility to ensure safe movement of healthy seeds internationally.

Phytosanitary certification of seeds for export and compliant with importing country requirements remains a core obligation of Contracting Parties to the IPPC. Importing countries are obligated to require the application of measures that are consistent with the principles outlined above. Risk analysis provides the basis for setting requirements for the import of seeds. Risk analysis for quarantine pests involves evaluating biological or other scientific and economic evidence to determine whether a pest should be regulated and the strength of any phytosanitary measure to be taken against it. Risk analysis for RNQPs is applied only for seeds or plants for planting, and recognizes appropriate pest tolerance levels based on economic impacts on those plants. Zero tolerance is not likely to be a general requirement.

Many of the ISPMs provide for regulation of seeds (planting material), for example:

- ISPMs Nos. 7 and 12 – Export certification and phytosanitary certificate
- ISPM No 11 – Pest risk analysis for quarantine pests, including analysis of environmental risks and living modified organisms
- ISPM No 19 – Guidelines on lists of regulated pests
- ISPM No 21 – Pest risk analysis for regulated non-quarantine pests
- ISPM No 23 – Guidelines for Inspection
- ISPM No 28 – Phytosanitary treatments for regulated pests
- ISPM No 31 – Methodologies for sampling of consignments
- ISPM No 32 – Categorization of commodities according to their pest risk

Other relevant ISPMs in various stages of development or for which a specification (S) has already been developed include:

- S 34: Pest risk management for plants for planting in international trade
- S 21: Guidelines for regulating potato micro-propagation material and mini-tubers in international trade
- S 47: Reducing pest risks in the international movement of seeds of forest tree species
- S 42: Pre-clearance for regulated articles

Draft ISPM: Design and operation of post-entry quarantine stations

Seeds for planting are usually classified as high phytosanitary risk material and certification of seeds may require the application of a measure or a combination of measures to the crop, the production area, the commodity during transit or at post entry. Common conditions or requirements apply in the application of phytosanitary measures. For example:

An Import Permit: An official document authorizing importation of a commodity in accordance with specified phytosanitary import requirements. This is generally required for importation of seeds by NPPOs.

Certification Schemes: Normally registered with and approved or certified by NPPO with trace-back and audit systems established. Management options may consist of a combination of two or more measures. These options may be applied to:

- area of production (treatment, area of low-pest prevalence, area of pest freedom, monitoring surveys, etc);
- place or site of production (isolation in space or time, pest-free place, IPM);
- parent stock (e.g. treatment, resistant varieties, selection of propagating material);
- consignment of seeds (e.g. treatment, preparation and handling, sorting).

Pre-inspection/Pre-clearance: These strategies are used to facilitate trade logistics at the request of the exporting country; Contracting Parties may bilaterally negotiate an agreement for allowing clearance in the country of origin by the NPPO of the country of destination. Joint auditing of the export certification system to facilitate new trade may be negotiated.

Select Entry Ports: Based on but not limited to the following criteria:

- skilled staff with competence in compliance checking;
- inspection and testing capability/facilities;
- disinfestation facilities;
- post-entry quarantine facilities.

Post Entry Quarantine (PEQ): May include different levels of security, for example, field site, screen house, glasshouse and/or laboratory. Location, physical and operational requirements, systems for diagnosis and treatment of quarantine pests and auditing of the station should be considered in the establishment of PEQ stations. The type of PEQ station to be used should be determined by the type of imported seeds and associated quarantine pests.

Recommendations

Considering the importance of a safe international seed trade to food production, it is important that partners, where appropriate,

1) Understand an importing country's requirements
Exporting partners should respect and fully understand phytosanitary regulations of importing countries. Non-compliant consignments may increase the risk of pest introduction and spread. Credible certification of seeds promotes market access and maintenance.

2) Use of ISPMs
ISPMs as minimum requirements provide guidance and recommendations that are applicable to the seed trade; for example, on inspection methodology, pest risk analysis and risk management, recognition of pest-free areas, phytosanitary certification. Trade partners should study the provisions of the ISPMs and apply them where appropriate in order to avoid unnecessary trade conflict.

3) Enhance cooperation
Establish strong linkages between seed associations, NPPOs and the IPPC in order to promote greater understanding, information-sharing and consistent action on issues regarding safe trade in seeds.

4) Develop national pest lists
NPPOs should strive to have national surveillance and national pest listing programs embedded in policy, recognizing that these programs underpin technically sound decision-making in the application of phytosanitary measures.

References

Glossary of Phytosanitary Terms, 1999. ISPM No. 5, FAO, Rome.

New Revised Text of the International Plant Protection Convention, 1997. FAO, Rome.

Oerke EC, Dehne HW, 2004. Safeguarding Production - Losses in Major Crops and the Role of Crop Protection. *Crop Protection*, 23:275-285.

Pimentel D, 1997. Pest Management in Agriculture. In *Techniques for Reducing Pesticide Use*. D. Pimentel (ed.), pp.1-11. John Wiley & Sons, Chichester, UK.

Discussion

GARLICH VON ESSEN (ESA): You mentioned quite a number of ISPMs that also deal with seed, but do not deal with seed specifically. And you also said that seed should be looked at even in a more stringent manner because it is a high-risk material. Well I think there is also a possibility to look at it from another angle, because it is a material that is already very regulated, very closely watched, by the people who own the seed, because it's so valuable. So I think people who trade in seed usually know very well what they do and how they do it and how to make sure that they have a high-quality seed. But would it be an idea also for a better spread of information to think about a specific ISPM for seed only? Pooling all the information that you have in the different parts of other ISPMs make it more logical, maybe more accessible for all the IPPC members. Could that be an idea or is it too complicated?

JEFFREY JONES (IPPC): I think that is a good question in the context of what we are discussing. However you need to understand the process of procedures to which ISPMs are converted. If you feel that it is necessary, or there is an information gap, and that you think the IPCC could consider a topic specifically on seed, I think, through the process of standard setting, you can give to us that sort of topic which could be considered.

MICHAEL MUSCHIK (ISTA): I have a question because we want to strengthen the collaboration between ISTA and IPPC. I see moderate progress, so I wanted to ask you what your ideas are for strengthening collaboration in the future. I think that from the ISTA point of view, there is a lot we can offer in regards to sampling, in regards to identifying wheat seeds, in having methodologies for seed testing. Do you have any proposals on how we can make quicker and faster progress there?

JEFFREY JONES (IPPC): The Chairman may correct me if I am wrong, but is ISTA actually invited to our CPM meetings?

JOHN KEDERA (CHAIR): Yes, they have been to all CPM meetings and the element of collaboration has come up. There is a proposal that is on the table, but it hasn't been progressed. And I think that could come in the general discussion if it has progressed to the next level, rather than you getting into it. I hope I have answered your question because I am aware of the issue you raised. It is something that can be pursued.

AAD VAN ELSEN (PLANTUM, THE NETHERLANDS): I have a few questions. I would like to talk about shared responsibility. It is something that really appeals to the private sector, and we have heard a lot about public-private partnership, but I must say that in the field of phytosanitary regulation that is still far away. For example, if you see the example given by the first speaker from Iowa State; in several regions it's possible for companies to do their own phytosanitary inspection, even for quarantine pests. Now in the EU that's not possible. My first question would be: What is the role of IPPC there, since you are talking about harmonization? This is something the seed sector and the plant sector really want; that companies take responsibility for their own product under some sort of accreditation. Now the same thing applies a bit to the whole question of PRAs. The PRAs sometimes seem to be the new trade barrier. Every country that has the right to ask for PRAs can ask for them, and although you claim that they should always be technically justified, they are not always technically justified. There is no mechanism to control that. So one of the things that the IPPC should set up is some sort of dispute settlement, in order for the companies or trade organizations to have at least a discussion when they think a country is technically unjustified to make a request for a PRA. The last thing you said was that there should be linkage between seed associations and PPOs and the IPPC. Now at national level, sometimes that works. But I think that also the IPPC should get into the linkage and at least allow the ISF and ESA or whatever organization to be an official observer at their meetings. So far, we have never been allowed. I think that is a step that the IPPC could take very quickly with, for example, UPOV to be official observer. Because we have something to contribute, and I think that should be more valued than it has been done until today.

JOHN KEDERA (CHAIR): I would first of all like to ask you to check the facts on the statements just issued. In terms of what happens in countries, I think if the people responsible for seed certification are separate from those dealing with the phytosanitary issues, you will always end up with a territorial competition. And this is a global issue that is actually being looked at, because there is also this sort of competition. In terms of the ISF being an observer sometimes at the IPPC, I think I have seen them at the CPM. And in the CPM, there is a dispute resolution mechanism which nobody yet has applied to use. So I would like you to check the facts. But I take your questions very positively because we need to get information out to all participants in order to accurately facilitate a good regulatory framework, because you are talking about a trend, and market development. We will get back to this question during the general discussion.

HARMONIZATION OF SEED TESTING FOR THE FACILITATION OF TRADE

Mr. JOËL LÉCHAPPÉ*

Introduction: Methods for Assessing Seed Quality: Measurement Tool or Factor for Competition?

In agriculture, and more generally in plant biology, where biodiversity is a fundamental element of development, talk of harmonization may seem a paradox. So why is it so important to harmonize and standardize the methods of quality control of seed? Would it not be simpler and less expensive to let the competition follow its own paths?

In terms of quality seeds, what is expected from farmers, the seed trade and regulatory bodies is seed that produces a healthy crop at a fair price.

The value of the global seed market is modest (37 billion US dollars), but this trade has an important role in the overall seed industry. In a competitive market it must be possible for the buyer or user to compare the quality of available seeds. To facilitate this, seed quality control must deliver in good time essential information on seed lots. Methods of assessing the quality of seed should therefore be regarded more as measureing tools for industry players, rather than as elements of competition. Competition is related to the quality of seed not to the method of quality measurement.

Broadly speaking, and in all industrial, scientific and commercial areas the initial establishment of trade is based on certain common factors:

- methods of measurement standards;
- standard units (metric, decimal, mass in kg, watt, degrees, etc.);
- common communication tools for centuries using a common language (scientific Greek, Latin, French, German, and English). To these we can now add modern tools of communication (telephony, Internet, etc.).

The trade of seeds is no exception. That is how the demand from the trade for an internationally accepted test report as a communication tool on seed quality has been the starting point for harmonization of seed-testing methods. Therefore, to answer this demand international seed organizations aim to develop and harmonize methods for analysis of seed quality. Among them, I allude to the ISTA (International Seed Testing Association) and AOSA (Association of Official Seed Analysts in North America). The ISTA, which is the subject of this presentation, has since 1931 proposed standard tools for measuring seed quality supplemented by an international means of communication.

In this presentation we will first describe the harmonized approaches at the international level that ISTA has made in terms of standardization of analysis methodology and the communication of results. In the second part, we examine the benefits of harmonized analytical methods to major clients and regulatory bodies and the contribution of such methods to the development of regional and international seed production. The presentation concludes with a reflection on the future of method standardization.

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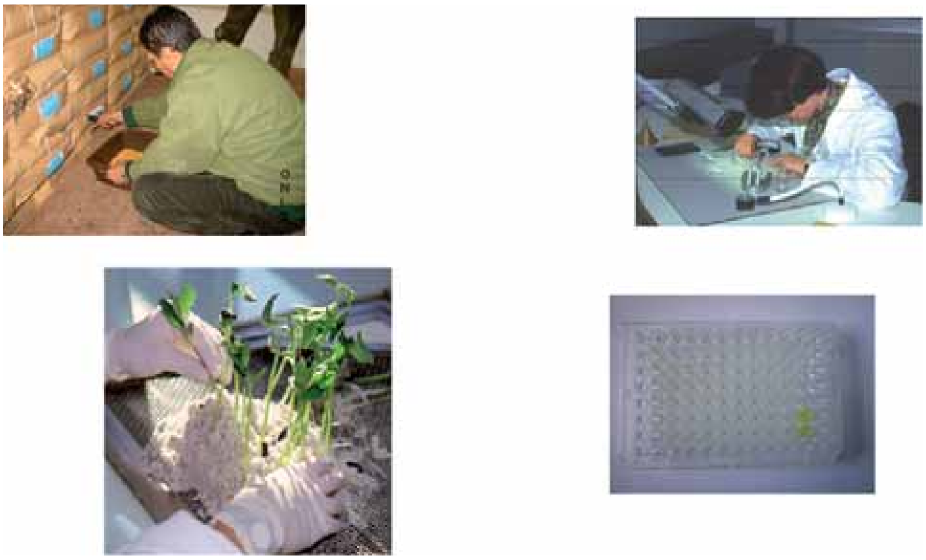
1. The Harmonization of ISTA Testing Methods for Seed Testing Quality: A Process constantly evolving with its Environment.

1.1 The Main Methods of testing the Quality of Seeds and their Applications

The pillars of seed quality control tests used regularly for trade are:

- Analytical purity, other seed determination, germination and moisture content tests. The total number of these tests can be estimated at several hundred thousand per year worldwide.
- Since the 1960s, diagnostic seed-health tests and more recently tests for the detection of GMOs have expanded considerably.
- Other laboratory tests, such as vigor, tetrazolium viability and varietal purity, are used less for the trade of seed. They are mainly developed in order to provide information on the performance of seed lots or on their conservation and storage (Fig. 1).

Fig. 1 Standard Methods for Evaluation of Seed Quality (sampling a seed lot, purity testing, germination testing, seed-health testing e.g.an ELISA assay)



1.2. Identifying Methods needed by the Seed Sector

The ISTA has an international reputation: its members represent 74 countries and are drawn from analytical or research laboratories in the public sector as well as from the seed industry. This position at the interface between research, industry and regulation greatly facilitates the identification of needs for new methods or changes in existing methods. In particular, members of the Association are at the root of many projects involving the development of new validated methods through ISTA technical committees. In addition, the strong participation of government representatives (Table 1), as members appointed by the designated authorities, and close contacts with international organizations (such as FAO and the OECD) and organizations in specific regions of the world (such as African or Asian bodies) play a major role in the strategic development of ISTA and its methods. The emergence of new regulations, such as the control of GMOs, phytosanitary requirements and health surveillance or the reduced use of pesticides, are carefully considered and taken into account.

The industry and its representatives at the global level (ISF) or at regional levels demand analytical methods to meet trade requirements and to control risks related to quality. Here the need for detection methods for GMOs is in everyone's mind as is the sanitary quality of seeds, especially among vegetable species where it is a major criterion. The partnership built between the ISTA and the ISHI/ISF (International Seed Health Initiative) is based on their complementary skill sets. The ISHI identifies the major pathogens of interest to industry and is developing protocols in partnership with the ISTA Seed Health Committee.

Thus, the methods in the ISTA rules are there to either meet regulatory needs (e.g. purity, germination, phytosanitary) or to satisfy technical and commercial evaluation objectives regarding the potential of seeds (e.g. vigor, state of health). They are a tool whose use is completely open to all users.

Table 1 Regional Distribution and Status of ISTA Member Laboratories

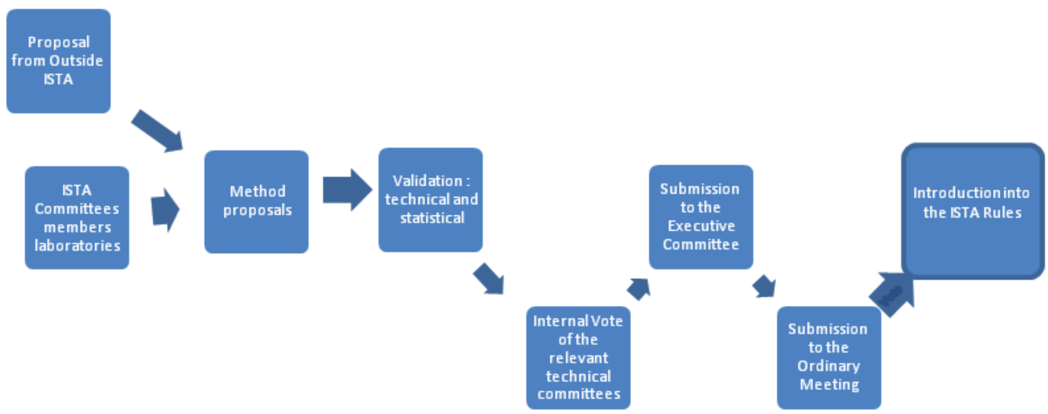
	Total	Private independent	Seed companies	Governmental
	2008	2008	2008	2008
Africa	16	0	3	13
Asia & Pacific	51	4	14	33
East Europe	33	0	5	28
West Europe	57	4	13	40
North America	12	5	2	5
South America	13	0	2	11
Total	182	13	39	130
2008: 182 member laboratories worldwide				

1.3. The Method Validation Program: A Guarantee for Transparency, Relevance and Traceability

To meet the expectations of the trade, methods of quality evaluation must be robust, repeatable and reliable whatever the region where the analysis is made. Ab initio methods introduced into the ISTA Rules had to undergo a validation process, admirably described in a recent article by Steiner et al.,2008: "ISTA Method Validation 2007: A Historical Retrospect". Seed Testing International. This process has been formalised into a series of steps (Fig. 2) described in the ISTA Method Validation for Seed Testing 2006, published on the ISTA website *http://www.seedtest.org/upload/cms/user/ISTAMethodValidationforSeedTesting-V1.01.pdf).*

The ISTA is completely open to all proposals for new methods which may be proposed by an ISTA technical committee, by a stakeholder or by someone outside ISTA. Proposals are developed by the technical committees who provide scientific and statistical evaluation. This is followed by a review by the Executive Committee of the competence of the method in terms of the objectives and policies of the association. The proposal is then submitted to a vote by the General Assembly, composed of members appointed by governments. Finally, new methods are included in the ISTA Rules which are updated annually. The total duration of the validation process for a new method varies from one to three years depending on the complexity of the study. Validation studies are published on the website of the Association, which ensures transparency, traceability and the scientific robustness of new methods.

Fig. 2 The ISTA Procedure for Validation of Seed Testing Methods



1.4. Communicating the Results in a Standard and Comprehensive Way: the Orange and Blue International Certificates

The ease of reading and understanding the results of analyses is an important element in communicating the results of these analyses for the trade of seed. This is why ISTA Rules give detailed prescriptions on the presentation of test results (units, precision = number of decimal places, methods) as this helps improve interpretation. However, depending on their use, the results can be published on different types of test report.

- For local commerce they can be on a test report that is particular to the laboratory that conducted the test.
- For domestic trade they can be on national or certification test reports, often with the logo of the certification authority and/or national accreditation body (ISO 17025).
- At the international level they are generally on ISTA certificates (orange for lots of seed, or blue for seed samples) and these certificates are used for import/export transactions.

ISTA International Certificates with their ISTA logo guarantee the identity of the seed lot with a single reference; the traceability of the analysis; the competence of the laboratory that made the analysis; the use of referenced methods and standard units; the use of standard reporting languages (English, Latin and others). Today, the ISTA Orange International Certificate (OIC) is widely used (Table 2) for international trade. This is the identity card of seed lots, the pass at many borders and the technical and administrative requirement of many contracts. The OIC is at the top of a pyramid consisting of a set of processes and rules that guarantee the value of the results and form the link between these and a seed lot consignment.

Table 2. Use of The International ISTA Orange Certificate for International Trade (Fig: Sales of ISTA Certificates from 2001 to 2008 "Activity Report of the ISTA Committees, 2008", 30-87)

Type of certificate	2001	2002	2003	2004	2005	2006	2007	**2008**
Orange	98 100	95 700	81 950	123 880	70 300	116 000	124 270	**110 517**
Blue	3 700	6 070	6 950	6 060	2 412	5 090	6 800	**6 050**
Total	101 800	101 770	88 900	129 940	72 712	121 090	131 070	**116 567**

1.5. A Quality System to ensure Uniform Application of Methods: The Accreditation of Laboratories

To strengthen the system of validated standard methods and standard methods of communicating results, a process to ensure the correct application of methods by all laboratory users should be in place. In 1995, ISTA established a program of laboratory accreditation for seed testing (see the ISTA website for the latest version of the ISTA Laboratory Accreditation Standard) *http://www.seedtest.org/upload/cms/user/ISTALaboratoryAccreditationStandard_Version5.pdf*).

To be an accredited candidate, laboratories must establish a quality assurance system, pass audits and obtain satisfactory results in the ISTA proficiency test program. Compared with standards such as ISO 17025, the ISTA standard is designed specifically for seed laboratories carrying out seed quality tests in accordance with the ISTA Rules. The opening of this program to company as well as government laboratories increases the diversity of contributions to ISTA, integrates the needs of industry and facilitates the development of ISTA methods within companies.

Accreditation ensures the competence of laboratories, their independence, impartiality and operation according to a common standard, regardless of the region of the world in which they are based (Fig. 3). The requirements are common to all laboratories but there is flexibility and diversity in the means used by laboratories to meet requirements. The methods of the basic tests such as purity or germination rely mainly on human and technical solutions. The solutions can be tailored to meet the needs of the particular situations of individual laboratories. For example, the control of germination substrates makes use of conductivity and PH meters, but if these are not available, an unsophisticated suitability test can be carried out by germinating indicator species on the substrates. Therefore, control procedures of direct relevance are available to laboratories whatever their level of access to scientific equipment.

The map (Fig. 4) shows the distribution of accredited laboratories. Irrespective of the country and the techniques they use to test in accordance with ISTA rules, these accredited laboratories can analyse seed quality with the same level of reliability. They can apply their techniques to the analysis of seed lots for domestic purposes or for import and export purposes. They are, in effect, autonomous and masters of their own trade.

Fig. 3 Regional Distribution of the 106 ISTA-accredited Laboratories (as of December 2008)
(Activity report of the ISTA committees, 2008)

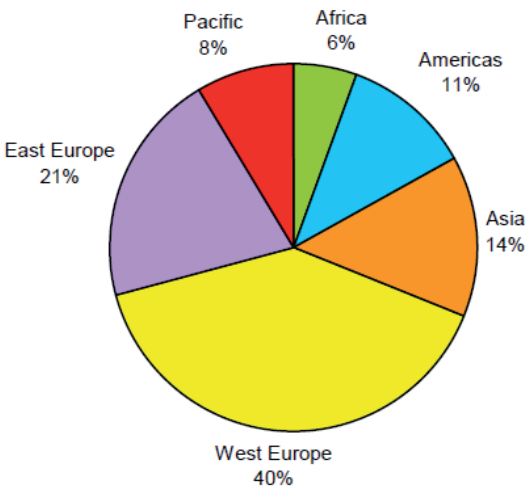
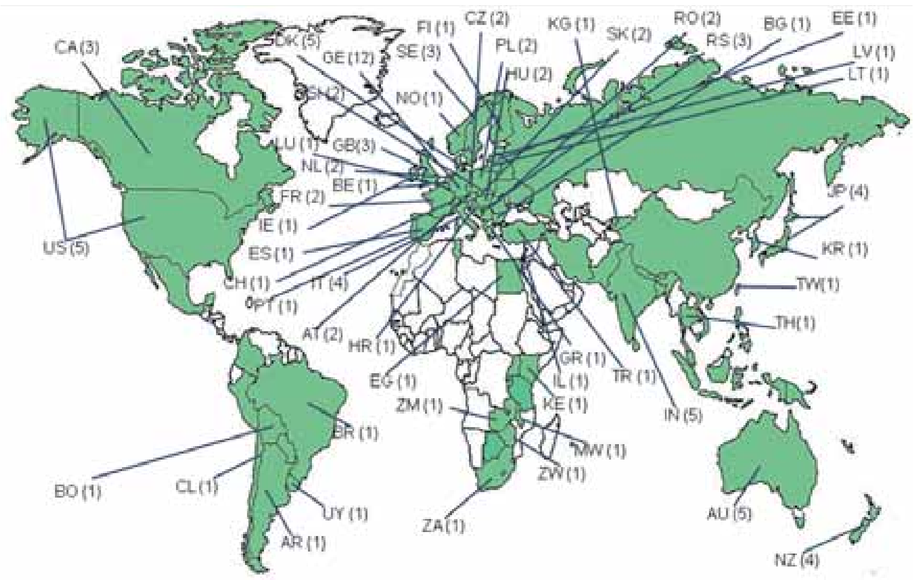


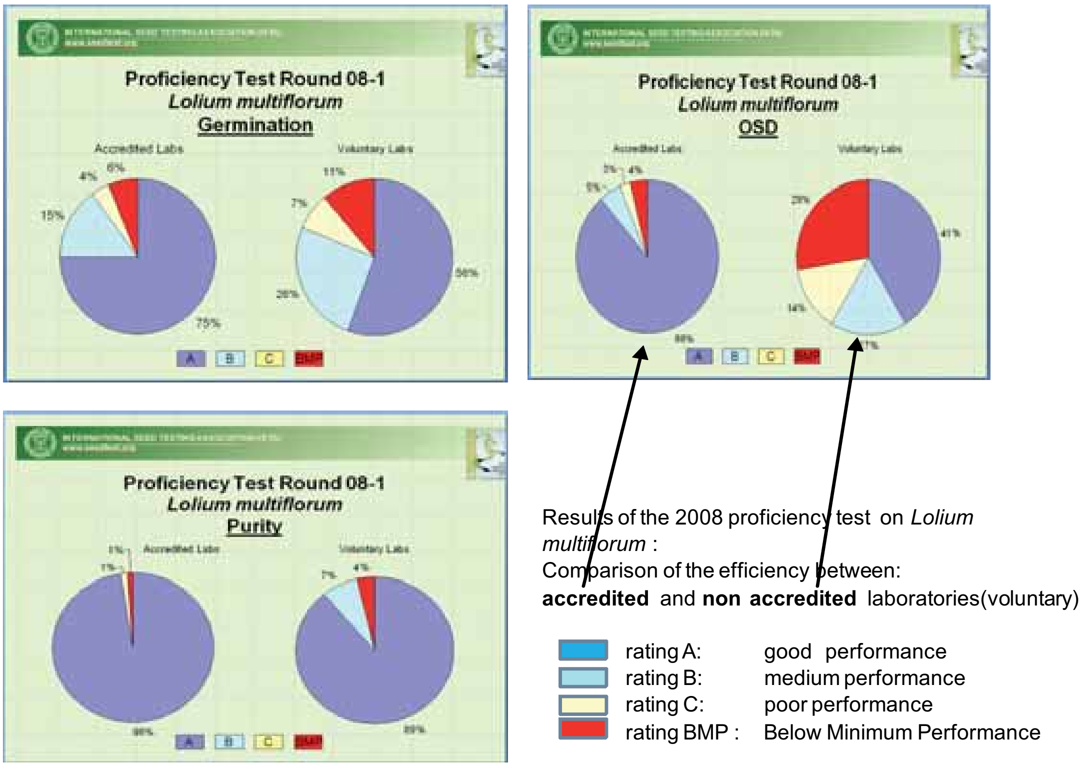
Fig. 4 ISTA-accredited Laboratories Worldwide



1.6. Verifying the Competence of Laboratories through a Global Proficiency Test Program

The requirement of resources and skills guaranteed by the accreditation standard is complemented through the verification of the reliability of results with an extensive proficiency test program. All areas of testing are covered: purity, germination, moisture content, tetrazolium, vigor, seed health and GMO testing. The proficiency tests guarantee the equivalence of the quality of measurements made with the same methods, the same skills and with the results presented in the same way. The frequency of proficiency testing ensures that laboratories use updated methods in the ISTA Rules for their analyses. The Minutes of the Committee of ISTA Proficiency Tests (Muller, 2008), clearly demonstrate that accredited laboratories achieve the greatest consistency of results in comparison to volunteer laboratories that have not yet achieved accreditation. The pie charts in Fig. 5 clearly demonstrate the benefits of accreditation even when laboratories are using the same standardised methods. Accreditation ensures that laboratory assistants are trained and qualified to apply the methodology to obtain a meaningful assessment of quality.

Fig. 5 Results of the 2008 Proficiency Test on *Lolium multiflorum*: Comparison of the Efficiency between Accredited Laboratories and Non-accredited Laboratories



Source: (Muller, 2008, ISTA Activity report 2008, Proficiency Test Committee)

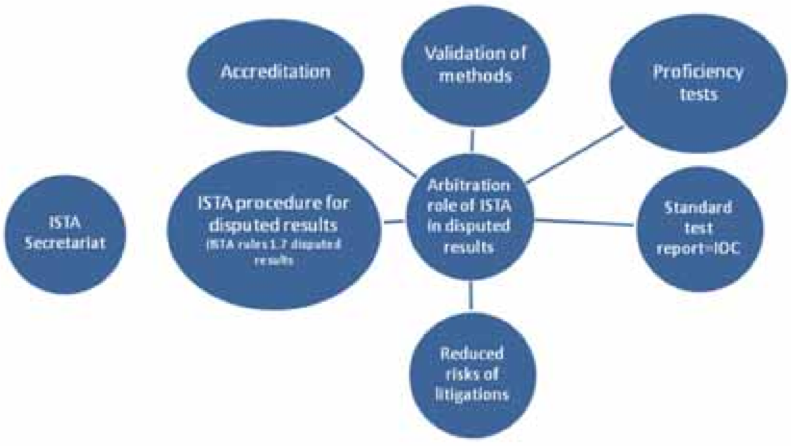
1.7. Training completes the Approach and Assures Knowledge of Modern Methods

Training is an essential component in the mastery of methods of analysis. Workshops, meetings and the use of ISTA publications in seed analyst training are important. Training carried out in different regions in partnership with other international organisations, such as FAO, have a double benefit in that as well as enhancing the application of existing methods, it is possible to gather information on the needs and requirements for method development in different regions of the world.

1.8. Managing Disputes between Laboratories

The whole approach described minimizes differences in evaluating the quality of seed lots by accredited laboratories and this in turn minimises the possibility of disputes. Where differences occur, a process managed by the ISTA Secretariat (ISTA Rules 2009, Chapter 1) makes it possible to quickly resolve matters (Fig. 6). Most disputes arise as a result of non-accredited laboratories approximately applying the ISTA Rules. In such cases the damage can be substantial and the resolution procedures lengthy.

Fig. 6 Disputed Results, A Simple and Efficient Procedure to reduce the Risks of Litigation



2. Harmonized Testing Methods and Validation, a Tool for the Production and Trade of Seeds

2.1. Who are the Users of Standard Methods?

In all the presentations at this Conference, we are constantly reminded that seeds are the basis for food and industrial development. At the end of the 19th and early 20th centuries, it was customary to require a "sound and fair market" for seed (Semences saines, loyales et marchandes, (Schribaux, 1884-1951)). Since the first edition of the ISTA Rules and the advent of international certificates in 1931, the evaluation of seed quality based on internationally recognized methods has spread gradually. Their use by interested parties varies according to their needs.

- The primary users are the ISTA-accredited laboratories and members of ISTA. These are official laboratories, seed company laboratories or private laboratories. Many other laboratories are not members but use the ISTA Rules for evaluating seed quality. These include company laboratories that test seed quality before marketing or for certification using the same methods that are used for official controls. Others who make similar use of the ISTA Rules are laboratories working for agricultural cooperatives or unions and private independent laboratories for whom seed testing is a business. Research laboratories use ISTA Rules for testing new methods in comparison with standard methods. In all cases, tests are conducted to answer questions from customers or regulatory authorities regarding licensing, certification, import/export and trade in general.
- Governments, particularly those who adhere to the OECD system of certification, have established systems of seed certification in support of their national regulations based on ISTA or AOSA methods. This is also the case in the EU where seed marketing directives require the use of international seed-testing rules. ISTA is very careful to ensure that changes to the rules of analysis take account of the expectations and constraints of these users. The addition of new methods, based on technical validation and a vote on their inclusion by designated members representing governments, according to the ISTA Constitution, gives an important guarantee to this stakeholder group.
- National seed industries include the use of ISTA methods in contractual agreements covering the production and trade of seed. At an international level the ISF uses the ISTA Rules for the marketing of seeds.
- More and more national accreditation (for example, UKAS: the UK Accreditation Services and COFRAC: the French Accreditation Committee) refer to ISTA methods in their programs of accreditation of seed laboratories to ISO 17025.

2.2. Test Methods can be a Precursor to Regulations

For decades, strong ties were forged between the methods and regulatory developments and the seed industry. It is interesting to note that often the methods existed before the introduction of regulations. This was the case in Europe where, since 1930, the availability of methods has preceded the development of national regulations. The possibilities offered to monitor the quality of seeds with proven methods contributed to political plans to extend the development of agriculture after the Second World War (Marshall Plan). In 1966 the first guidelines for certification of seeds based on checks of analytical purity and germination appeared almost a century after the initial development of these tests by the founding fathers of seed testing. In the 1990s, major work on the harmonization of approaches between ISTA and AOSA enabled the EU and the US to establish equivalence arrangements that greatly facilitate the exchange of certified seeds from North America and Europe. Today most regulations that facilitate trade are based on internationally recognized methods.

2.3. Test Methods and Standards for Quality are often closely related

Following the parallel developments of methods and rules, links were gradually woven with legislative standards. For example, in Europe, according to the Oil and Fibre Plant Seed Directive (Directive 2002/57/EC, 2002; Directive amendments - 2002/68/EC, 2002) the maximum rate of contamination of sunflower seed by Botrytis is 5 per cent. However, the meaning of this quality standard is related to the size of the sample as shown in Table 3. The risk of certifying contaminated lots with more than 5 per cent Botrytis increases as the size of the sample decreases.

Table 3 Influence of Sample Size on the Risk of making a Wrong Decision for Certification of Sunflower Seed Lots contaminated by Botrytis cinerea (EU certification standard: maximum 5 per cent of contaminated seeds in a sample of 400 seeds) (Lower and upper limits are the limits of the confidence interval)

		limits of the confidence interval	
Thresheld 5% contaminated seeds	400 seeds tested	lower limit 3.08 %	upperlimit 7.62%
	200 seeds tested	lower limit 2.42 %	upperlimit 9.0%

In the same way, the level of purity is directly influenced by the definition of pure seed. Jensen (2009) reminds us in his article on the history of purity entitled: ISTA Purity Analysis and Determination of Other Seeds by Number from 1924 to 2006, that the test of purity has evolved from the “strong method” to the “quick method” more suited to the needs of the seed sector.

We cannot therefore divorce the test methods used to check the quality of seed lots from the legislative standards used to control seed quality.

2.4. Methods are evolving to meet the Needs of Production and Commerce

The development of test methods follows very closely the needs of the seed sector in general. For the record I cite five examples:

- Historically a starting point for harmonization was the demand from the trade for internationally accepted test reports resulting in the ISTA Orange Certificates, and the ISTA Rules.
- The OECD demand for test methods applicable to seed mixtures (mixtures of species) that are becoming increasingly commercialized.
- Applications from the ISF to increase the size of seed lots to suit the conditions of production and transport. The size of seed lots of sorghum and vegetable pulses increased to 30 000 kg. after studies in 2008 (ISTA Rules, 2008).
- The growing need for methods to detect pathogens on seeds in the context where it is crucial to produce healthy seed to reduce pesticide use and produce more food. In the years 1960-1970, research into the development of analytical methods in microbiology, immunology and serology greatly benefited the quest for new seed-health tests. The same is now true for developments in molecular biology. These developments have led to the production of analytical methods for detecting seed-borne infection by fungi, bacteria, viruses, nematodes. Today, even if all markets

do not require regulation, control of sanitary quality of seeds for both national and international markets has become, in many cases, a major issue. To address the growing need for methods, it is crucial to consolidate the forces available. As a first example, the ISF, in creating the ISHI (International Seed Health Initiative), is a good illustration of this. The close partnership established between the initiator ISHI, who established the needs of industry and the ISTA Seed Health Committee, initiator of ISTA methods and responsible for the validation of methods, helps to advance the methods of detection of pathogens on seeds and gradually meets the needs of the seed trade. Another example is the case of the Consortium "Clavibacter", where the combined efforts of the EPPO, the plant protection organizations, the official seed-testing laboratories of European countries and the seed companies, allow quick progress in the setting-up of new methods by pooling resources.

- Finally, with the urgent need for methods to detect GMOs, ISTA has established a network of partner agencies, businesses and international organizations. This has led to the development of a system based on performance-based methods to overcome the lack of standard methods. However, today, many other organizations responsible for standardization of methods, such as the ISO (International Standard Organization) and ENGL (European Network of GMO Laboratories), are working on the standardization of methods for detection of GMOs in foods, plants, and by default in seeds. There is a risk that the methods developed may only be partially adapted to seed and this could create difficulties in commercial transactions. The combined experience of those involved is an issue that needs to be considered carefully, taking into account the specificities of seed.

2.5. Seed Testing Methods: A Tool to contribute to the Seed Production Programs in Specific Regions of the World

2.5.1.Methods for Tropical and Sub-tropical Species

ISTA is highly sensitive to the need for methods for poorly endowed parts of the world. Decades of work in Europe, America, Australasia, North Africa and the Mediterranean region have given results that we must now turn to the tropics and sub-tropics.

Within the priorities set out in ISTA, all technical committees develop programs on tropical species. For example, in 2009, the germination validated a method for Brachiaria brizantha (Aranciaga, 2009). However, the magnitude of the task requires resources well beyond those currently available to the ISTA committees. We need more laboratories to participate in trials and more seeds for the tests. A close partnership between ISTA and those involved in seed quality work in tropical and sub-tropical regions would accelerate the development of methods for these regions.

Fig. 7 Proposal of a Germination Method for a New Species: Brachiaria brizantha

ISTA validation study on germination testing of *Brachiaria brizantha* (A.Rich.) Stapf [Rules Proposal 2010 B.1.]

Ignacio Aranciaga, National Seed Institute, República Argentina

Summary

A validation study on germination testing of *Brachiaria brizantha* was carried out. Six laboratories were involved and each tested 400 seeds of three seed lots. The analyses of the results demonstrate that the following method is of sufficient repeatability and reproducibility to be included in the ISTA Rules:

Table 5A Part 1 Agricultural and vegetable seeds

Species	Prescriptions for:				Additional directions including recommendations for breaking dormancy
	Substrate	Temperature (°C)	First count (d)	Final count (d)	
1	2	3	4	5	6
Brachiaria brizantha	TP	20-35	7	21	KNO_3; predry and KNO_3

(extract : 06-2009 ISTA Method Validation Report 2009)

2.5.2. Assistance to Seed Production Programs in Specific Regions of the World and their Contribution to Increased National Autonomy for Control and Trade of Seeds

There are many programs for the development of seed production in developing countries. Sources of aid management and financing are quite diversified; there are many FAO projects and partnerships in the framework of programs supported by the European Union. These programs usually include a methodology component designed to assist laboratories in training towards a mastery of analytical methods that are required for accreditation. This assistance is usually provided by experts from laboratories of the partner countries who are also members of ISTA. The close relationship that is established during training gives recipients the opportunity to establish contacts with networks of laboratories accredited by ISTA.

The availability of standard methods is recognized internationally as one of the pillars of the production of seeds for agricultural development. In industrialized countries; the availability of methods for checking the quality of seeds has always been a great support for the seed industry and for governments in seed production programmes. In developing countries, where seed production is insufficient, the availability of internationally recognised methods is a first step in the setting-up of national seed production schemes: it facilitates the elaboration of regulatory standards such as seed certification. This allows countries to structure their seed production on recognized methods of control and become more independent in the assessment of seed quality and, consequently, in the control of the import and export of seeds. This facilitates trade.

Conclusion: What Future for the Harmonization of Methods?

A long road has been travelled since the inception of ISTA in 1924 and the publishing of the first international Rules and the creation of the Orange International Certificate in 1931. Used mainly by official laboratories for nearly 60 years, ISTA was opened up to the private sector in 1995 when it was also allowed to join and issue certificates. The standard methods listed in the ISTA Rules are now embedded in laws; in regulations; in programs of accreditation and they are widely used by industry throughout the world.

Tomorrow will we still need standardized methods? If so, will we be able to ensure the development of methods? Several lines of development can be proposed:

- Taking into account the evolution of analytical techniques such as molecular biology, machine vision and near infra-red spectroscopy to provide more efficient and effective analysis of quality attributes such as GMOs, pathogens and vigor.
- Taking into account technological advances such as priming, treatment and disinfection of the seed.
- Increasing the availability of methods for developing countries.
- Developing methods for tropical and sub-tropical species.
- Becoming aware of the increasing need for flexibility in methods, whilst ensuring that the needs of rigor and standardization are not neglected.
- Analyzing the cost/reliability, speed, ease of implementation of the standard methods and ensuring that they are available to all countries whether industrialized or developing.

In the medium term, there is good reason to be optimistic about the future of basic tests such as purity and germination. These tests are strategic for trade and are firmly rooted in national and international regulations. The development of these tests is guaranteed by the strength of the network of partners who all have the same goal: quality seeds!

But we, the seed sector, have to face questions. These questions come from the political and regulatory environment in which tests based on new technologies such as molecular biology are being developed. In the main these are tests for the detection of GMOs and the detection of pathogens in seed. Many organizations that work on foodstuffs, such as the ISO and ENGL for the detection of GMOs, or whole plants, such as the IPPC for the detection of pathogens, include secondary tests on seeds in their goals. On the one hand the seeds can draw benefits from this but on the other hand it may be risky to extrapolate standardized tests for food and whole plants to seeds. The general nature of tests on food and whole plants may make them unsuitable for seed.

To conclude: on the one hand I take the opportunity of this Conference to appeal for cooperation and the avoidance of competition which would be counter-productive and would inhibit gains in productivity that could be achieved if we worked in synergy. On the other hand, I hope that all players in the world of seed have common aims and policies: i.e. the development and standardization of tests including those for GMOs and health diagnostics.

ISTA can lead these projects in close partnership with existing organizations and with the support of governments and industry. It will adapt to a changing agriculture.

Acknowledgements

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References

Aranciaga,I. (2009) ISTA Activity Report 2009. International Seed Testing Association. Zurich. Switzerland.

AOSA, (2008). Rules for Seed Testing. Association for Official Seed Analysts. US.

EU Directive 2002/57/EC, (2002). The Oil and Fibre Plant Seed Directive.

ISO/IEC, 17025,2005. General Requierements for the Competenece of Testing and Calibration Laboratories.

ISF, (2009). Rules and Usages for the Seeds for Sowing Purposes. Internatioanl Seed Federation. Nyon. Switzerland.

ISTA, (2008). International Rules for Seed Testing- Rules 2008. International Seed Testing Association. Zurich. Switzerland.

ISTA, (2009). International Rules for Seed Testing, *ISTA Rules*, Chapter 1. - Rules 2008. International Seed Testing Association. Zurich. Switzerland.

ISTA (2007). ISTA Laboratory Accreditation Standard, 1-9. International Seed Testing Association. Zurich. Switzerland.

ISTA (2006). ISTA Method Validation for Seed Testing-V1.0,2-70. International Seed Testing Association. Zurich. Switzerland.

Jensen, H. A., (2009).ISTA Purity Analysis and Determination of Other Seeds by Number from 1924 to 2006, *Seed Testing International*, 137, 5-60.

Muller, G. (2008). ISTA Activity Report 2008, Proficiency Test Committee. International Seed Testing Association. Zurich. Switzerland.

Schribaux, E. (1884-1951). Archives, internal document. Geves- National Seed Testing Station. Angers. France.

Steiner, A.M., Kruse, M. and Leist, N. (2008). ISTA Method Validation 2007: A Historical Retrospect. *Seed Testing International*, 136, 30-33.

Discussion

FRANÇOIS BURGAUD (GNIS, FRANCE): Yes, I have just a comment. The problem is related to the use of ISTA tests by governments. I will take the example of an Orange Certificate. At the beginning, the idea of an Orange Certificate was good; it was to facilitate private exchange. But now you have some countries, that even for seeds which are certified with an OECD or a European certificate, have a compulsory Orange Certificate. That is also a new trade barrier. For example, ISTA organized an accreditation of private laboratories. It is good. But it's good also as an intergovernmental organization to ask the countries who are members of ISTA to recognize the official analyses made by accredited laboratories of private companies. Because until now, you have some countries which don't accept Orange Certificates which were made by accredited laboratories from companies. And some countries request an official stamp of an official government. So I think there are also some problems with ISTA and the OECD on which they have to work.

JOHN KEDERA (CHAIR): Thank you for those comments; I don't think we need to react to that. We can then move to the last speaker.

HARMONIZATION OF THE SEED REGULATORY FRAMEWORK AT THE REGIONAL LEVEL – EUROPEAN UNION

Mrs. PAIVI MANNERKORPI

The European Union (EU) consists of 27 Member States representing a single internal market for around 500 million citizens. The European seed industry is the primary supplier to Europe's food and feed chain. The internal market for seed has been developed since the 1960s through EU Directives which apply in all the Member States, ensuring the freedom of movement of seed. In terms of monetary value, the EU commercial seed market (agricultural crops including seed potatoes, vegetables, turf grasses) has now reached around 7 billion euros. The EU seed market accounts for over 20 per cent of the total worldwide market for commercial seed. Moreover, the EU is one of the world's largest exporters of seed.

The EU legislation on seed sets the conditions for its marketing, aiming at providing guarantees of quality and health to users. The marketing requirements are composed of two pillars: registration and certification. Registration of varieties in the EU Common Catalogues is a precondition for marketing seed of agricultural and vegetable crops in the EU. For a variety to be registered, it needs to be Distinct, Uniform and Stable. Moreover, varieties of agricultural species need to meet criteria with regard to their Value for Cultivation and Use. Quality characteristics are also required for fruit plants, vine, and forest reproductive material as well as ornamentals. In the certification process, the requirements concerning varietal identity and purity, germination capacity and freedom from harmful organisms are checked. The responsibilities of the breeders, maintainers, producers and suppliers of seed are subject to stringent rules. The EU rules are aligned with the international standards of OECD Seed Schemes, UN-ECE, ISTA and EPPO.

As regards importation into the EU, the basic principle is that seed produced outside the EU is considered equivalent to seed produced in accordance with Community legislation, e.g. seed may be marketed within the EU if the seed affords the same assurances as seed officially certified within the Community. The seed should be officially certified and seed packages officially closed in accordance with the OECD Schemes for the Varietal Certification of Seed moving in International Trade. Seed sampling and testing should be carried out in accordance with the methods of the International Seed Testing Association (ISTA) or, where appropriate, with the rules of the Association of Official Seed Analysts (AOSA).

An EU plant variety protection system has existed since 1994. On the basis of a single application to the Community Plant Variety Office (CPVO), a breeder may be granted an EU-wide IPR for a plant variety that is new, distinct, uniform and stable. At present more than 16,000 varieties of plants are protected under this system. The EU rules are based on UPOV standards (1991 Act).

In addition, the EU Rules on the Community Plant Health Regime, GMOs and Organic Agriculture apply to seeds.

Further information can be found on the following web site: *http://ec.europa.eu/food/plant/index_en.htm.*

* Head of Sector, Unit for Biotechnology and Plant Health, Directorate-General Health and Consumers, European Commission

Discussion

CHAWDHRY UPMA (MINISTRY OF AGRICULTURE, INDIA): I have two linked questions. You mentioned the agricultural common catalogue. On what basis are the varieties entered in the catalogue? And secondly, is certification mandatory in your system? Or, in other words, do you have certified and non-certified seed or only certified seed? And in case there is a system to allow non-certified seed, what regulations would be applicable to that seed?

PAIVI MANNERKORPI (EUROPEAN COMMISSION): The requirements for the common catalogue are that there needs to be DUS testing in the Member States and also VCU testing. There also needs to be a denomination, a name for the variety, for fulfilling the rules. And this is done at the Member State level. So we have the rules but the actual work is carried out by the Member States and as soon as there is a variety incorporated in the national list, it will be notified to the Commission and we will add it to the common catalogue. As soon as it is in the common catalogue it can be marketed in the whole of the EU. So this is how we assure the movement of free varieties in the EU. Regarding certification, certified seed can be marketed in the EU. Our rules concern the major crops that are of major importance in the EU. So we don't have all crops in the scope of our regulations. If a crop is not covered by our regulations, then national rules apply. So the marketed seed should be certified seed. But we are aware of the situation that the farmers are using their own seed; they are not necessarily using certified seed. And coming myself from a Nordic country, we know this situation well. But they are taking certain risks if they are not using certified seed.

TAZI (FAO): We know that there are some private companies from the EU producing seeds outside of Europe. So if a certified seed in a given country which is not in Europe is imported by one country in the EU, is it freely traded within the EU community?

PAIVI MANNERKORPI (EUROPEAN COMMISSION): We have the EU regulation on equivalence and maintenance so if something is maintained outside the EU, it should fulfill these requirements, and also the requirements on imports.

TAZI (FAO): Well sometimes the seeds are certified by a national government or a national authority within a country, for example, in Africa. Then the seed from this company from the EU, that is thus produced outside of Europe, is imported in order to enter a given country in Europe, for example the Netherlands or France. Is the movement within the other countries then free? Is the seed in this situation freely traded within the EU?

PAIVI MANNERKORPI (EUROPEAN COMMISSION): That is an interesting situation. And I wonder if some of the Member States are in a better position to answer this question, because this is obviously a question of controls. But to answer your question, once the seed enters the EU then it can be marketed freely throughout the EU. However, at the entry point (country where the seed enters), the seed should really fulfill the requirements that I have outlined.

JOHN KEDERA (CHAIR): I think that's a challenge to the EU countries responding.

HOSEA SITIENEI (KENYA SEED COMPANY LTD): Occasionally we import seed from other countries, with very good germination results shown on the Orange Certificates. But when that seed is tested locally, sometimes it doesn't meet requirements. How should the importer be compensated? Because we rarely get compensated at all.

PAIVI MANNERKORPI (EUROPEAN COMMISSION): If I understood you correctly, when seed is imported, for instance, from Tanzania, it should fulfill these requirements with regard to the seed testing and the labels. ISTA certificates and OECD labels are required. Did I answer your question?

HOSEA SITIENEI (KENYA SEED COMPANY LTD): No, my question is that sometimes you get seed with very good results as shown on the Orange Certificates, but when it is tested in your own country, the seed does not meet the requirements. As an importer you lose in terms of time and money and you don't get any compensation at all. How should the importer be compensated?

PAIVI MANNERKORPI (EUROPEAN COMMISSION): Thus we are talking here about the compensation in the moment where some requirements are not fulfilled. I think that for this kind of question it's a matter of the agreement between the seller and the buyer. Our EU rules do not deal with compensation in the case of non-fulfillment.

AAD VAN ELSEN (PLANTUM, THE NETHERLANDS): I would like to make an addition to your comment. You mainly talked about certified seed, but I would like to add that vegetable seeds are not traded as certified seeds but as standard seeds and therefore they do not need any VCU. Also in your graph, on the turnover of the size of the market, it was only talking about certified seed and certain agricultural species and not vegetable species because that would change the data considerably.

PAIVI MANNERKORPI (EUROPEAN COMMISSION): Yes, thank you for this clarification.

GARLICH VON ESSEN (ESA): Just a comment, because this is also designed for exchanging experience with existing systems. I think what has come out of the evaluation so far is that farmers and breeders still face the same big issue and that is competitiveness. They also rely on the same pillars of the existing seed system in the European Union; DUS to ensure identity of varieties; VCU or, for vegetables, non-compulsory but similar quality standards to ensure performance and seed certification, or for vegetables, similar systems to ensure quality. All of that has worked well, and that has been the unanimous result of the evaluation that has taken place so far. So if you are looking for a blueprint for a successful system, this is it. However, as you mentioned in your speech, there are areas where improvements are required. And there is one I would like to point out: the challenges that arise from new technology, for example with GMOs. As soon as the systems start mixing up seeds with other things like food and feed, we get into trouble. If we stick to the way we are dealing specifically with seed, and try to find seed-specific solutions, things are possible and they are not even that complicated. But as soon as the seed system is challenged by trying to apply rules or standards that are not designed for seed, that is the moment when the seed industry and farmers get into trouble. Adventitious presence of GMOS in conventional seed is a typical example of that. It has been singled out as one of the main areas where improvements are required.

General Discussion

ISABELLE CLEMENT-NISSOU (GNIS, FRANCE): I have a question in relation to the IPPC. Yesterday we spoke of plant breeding on genetic resources and the plant treaty, but we also have to address the context of the Convention on Biological Diversity. Last April the European Union posed the question of access to genetic diversity to pathogens. I would like to know if the IPPC has addressed this question.

JOHN KEDERA (CHAIR): The IPPC representative had to go to another meeting, but what I know for a fact is that the IPPC deals with the pests on plants. So anything that becomes a pest on plants can accurately be dealt with in the context of the IPPC framework. That is the current position.

ISABELLE CLEMENT-NISSOU (GNIS, FRANCE): Thank you, it's our view, but did you address the question of access and benefit sharing? We always say that, when we have a more relevant forum, we have to go to the IPPC, to OEF for animal pests or to WHO for human pests, etc. But how will you address or are you prepared to address the question of access and benefit-sharing? Just in a few words, "yes", "no", or, "perhaps in few months".

JOHN KEDERA (CHAIR): Sorry I am attempting to answer the question on behalf of the IPPC; the consultations are I think between the IPPC and the other relevant body. I believe that at the next CPM we will have a clear statement. The next CPM is in April next year.

JOHN HAMPTON (ISTA): I would also like to come back to the IPPC. We know that the lack of sufficient seed health testing methods is one of the major problems we face in international seed trading. And while ISTA and ISHI have been working together for several years now on developing seed health testing methods, we have been desperately trying to get some sort of connection with IPPC, by "we" I am talking about ISTA. And to be frank, what has happened so far has been very frustrating. I would like to come back to our Secretary General's question on how, by the end of tomorrow, we can come up with a method where we do have the ability to work together and try to solve one of these most important problems for seed trading.

JOHN KEDERA (CHAIR): I think I attempted to answer that question when talking about the ISTA initiative for a collaborative arrangement with CPM. There was even supposed to be a joint workshop, a seminar in Geneva, but unfortunately the staff resources at the IPPC at that particular time were not strong enough to go through with the seminar, so it did not happen. But there is a commitment to work together to sort out the issues, and I think there was another question that was raised on whether we can have a consolidated ISPM that deals with seeds. These are the issues that can actually be discussed. So it is an issue and since I am currently on the advisory bureau of the CPM, I will raise it with the bureau at its next meeting. But it is an issue that needs to be discussed, particularly as we operate in our own individual countries.

MICHAEL MUSCHIK (ISTA): You mentioned that our joint seminar has been postponed on a request from IPPC. Has another date been suggested when we can have this seminar, has it been discussed in the bureau of the IPPC already? If not than please bring it forward.

JOHN KEDERA (CHAIR): Very well, point noted.

JUSTIN RAKOTOARISAONA (AFRICAN SEED TRADE ASSOCIATION): I have a general question for this session, especially on the seed trade. One issue that the industry is facing is the issue of re-exports. Seed is produced in one country and then it is brought to a second country, and from there it is exported to a third country. Now under the IPPC, can we take up this issue? Suppose that a seed producing country, for example Chile, is given the phytosanitary certificates with all the additional declarations, and then the seed goes to Japan and from there, the seed has to be exported to South Asia. Now the NPPO and Japan will not issue the same additional declarations that they have been getting from Chile. This is one of the serious issues that is affecting the seed trade, so I was wondering if we could address this issue. And the second issue regarding the IPCC members or the NPPOs is: Can they trust each other's declarations?. A certificate is issued from Holland, and when it goes to, let's say, the Philippines and the Filipino NPPO says they don't trust this certificate, we have to do all these things again. Then it takes one or two months. So this is the practical issue we are facing in the seed industry.

JOHN KEDERA (CHAIR): There are guidelines on the issuance of our export certificate. And that is what should guide national plant protection organizations in the issuance of the phytosanitary certificate. Now, if it is not in compliance, or if it is not issued in conformity with that guideline, than it is an issue that needs to be looked at. But I can sympathize with the issues that you have raised, because all of the NPPOs tend to be separate entities and they have guidelines. And I think that's what one person has raised here; whether or not the NPPOs need to work together with the rest of the seed systems so that you have almost a one-stop shop. Remember that each of the countries has a national system in place. And you cannot just go in and change it overnight; it takes a while. In some countries they work together and in other countries there are totally different ministries dealing with the issue. Even getting them to talk to each other is a challenge. So at the policy level it is an issue that needs to be raised, because if we don't raise it, then it causes problems to trade.

ADELAIDA HARRIES (IOWA STATE UNIVERSITY): I have several questions, one to Mr. Ryan. I would like to know what is the annual fee or the contribution for countries to join the OECD Schemes because that is a problem for developing countries to become members. The other question is for you, Mr. Chairman, about the activities that the NPPO can delegate to the private sector under the IPPC Convention or the SPM measures. Is there any activity that can be conducted by the private sector? And the other comment is, at the end of the first presentation, you mentioned that small companies in developing countries have a fear that big or multinational companies can come to these countries. Were you referring to a lack of the harmonization process? It wasn't clear for me.

MICHAEL RYAN (OECD): I will deal with the first question regarding the OECD fees. The fees are very reasonable. When a country applies to join the OECD Schemes, there is no fee for the application. It's only when a country becomes a member that a fee is paid. The fee that is estimated for a country is composed of two parts. There is a base fee – and the current base fee is 2,500 euros and that applies to all countries. In addition, there is a second part which is a scale formula. The scale formula is related to the size of the country, more specifically the economic size of the country. And there is a rating given to each country depending on its economic power in the world or its economic size in the global economy. For developing countries it is very low, whereas for the most developed and the larger economies it is much higher. So there is a base fee and a scaled factor, but overall fees are very reasonable.

JOHN KEDERA (CHAIR): Regarding the question on the delegation of phytosanitary activities. I don't know of any that are prescribed at the IPPC level, but the workings at the national level can come up with systems to address the competences that do exist. However, at the IPPC level we have not gotten into the delegation of responsibilities. But at the national level, there are many working models, as long as the NPPO finally takes the responsibility.

I would now like to close the discussion. You will have the chance to discuss more issues tomorrow at the policy forum. Therefore, I will move to attempting a summary of what we have discussed today, taking into account that we may not have exhaustively addressed all of your questions.

One is that we know the global market for seeds has increased tremendously. We know again that international certificates and labels are being used at an increasing rate, be they for variety certification or for phytosanitary measures. We also know that the international regulatory framework is accurately being applied in many countries. Also we have learned that regional frameworks have been developed, and most are based on what is happening at the international level. We have also seen that seed is a highly regulated commodity. That is because it is where production starts. In addition, we say that cooperation, partnership, understanding, appreciation among all the players, be they public, national, international, or private, is essential if we are to move to the next level. And implementation of measures, that may be different in all the countries around the globe, is key to the success of the seed industry.

Session 5. Conclusion, presented by the Chairperson
Facilitation of trade and market development

- Global seed market has grown rapidly in recent years and is currently estimated at about US$37bn. Europe, North America and Asia account for almost four-fifths of the global seed trade. For 2007, the international seed trade was estimated at US$ 6.4bn.

- The use of international certificates for varietal certification, phytosanitary measures and laboratory testing has greatly facilitated the development of the international seed trade.

- Production and marketing of certified seed of all agricultural crops is highly regulated at both the national and international level. A transparent and efficient regulatory system is crucial to ensure that farmers have access to high quality seed at a reasonable price.

- The international regulatory framework consists of certification based on varietal identity and varietal purity (OECD, AOSCA), phytosanitary measures (IPPC, WTO-SPS, NPPO), plant variety protection (UPOV) and seed testing (ISTA, AOSA, etc.).

- Regional seed regulatory frameworks have been developed and harmonised to facilitate regional trade e.g. Central America, Mercosur, EAC, SADC, ECOWAS, etc. Regional standards, such as those of the EU, are closely aligned with international standards such as those of the OECD and clearly set out the registration and certification conditions for the marketing of seed.

- The increasing use of harmonised international certification procedures on varietal identity and varietal purity helps to facilitate the import and export of high quality seed by assuring consumer confidence and reducing technical barriers to trade.

- Good cooperation between the public and private stakeholders in developing and setting standards that are internationally acceptable has facilitated the issuing of certificates which, in turn, has contributed to the growth in trade.

- Implementation of measures to prevent the introduction and spread of plant pests is critical to ensuring the development of a viable and sustainable global seed market. The International Standards for Phytosanitary Measures (ISPMs) provide useful guidance on the application of phytosanitary measures to the international seed trade.

Policy Forum

- **WELCOME**
  Mr. BERNARD LE BUANEC, Chairman of the Organising Committee

- **WELCOME**
  Mr. SHIVAJI PANDEY, Director of Plant Production and Protection Division (AGP), FAO

- **WELCOME ADDRESS**
  Mr. FRANCESCO BONGIOVANNI, Dirigente ufficio sementi, Ministerio delle politiche agricole alimentari e forestali, Dipartimento delle politiche di sviluppo economico e rurale, Italy

- **KEY NOTE SPEECH**
  Mr. M. S. SWAMINATHAN, UNESCO Chair in Ecotechnology, Member of Parliament of India and Father of the Indian Green Revolution

- **CONCLUSIONS OF THE EXPERT FORUM**

- **OVERVIEW OF THE EXPERT FORUM**
  Mr. BERNARD LE BUANEC, Chairman of the Organising Committee

- **PROVIDING AN ENABLING ENVIRONMENT (PANEL DISCUSSION)**

- **CONCLUSIONS OF THE 2ND WORLD SEED CONFERENCE**

WELCOME

Mr. BERNARD LE BUANEC*

Good morning Ladies and Gentlemen,

Welcome to the third day of the Second World Seed Conference. As you know, the first two days of the Conference were an expert forum, where we discussed technical issues in some detail. This third day is more a day for policy discussions based on the conclusions of the expert forum.

Today we will start with welcome speeches from a representative of the Director General of FAO and the Italian Ministry of Agriculture. Then we will have a key note address by Professor Swaminathan and after that we will have the presentation of the conclusions of each session of the expert forum. After that we will have a panel discussion on all those topics.

I wish you an interesting morning and I'm going to give the floor immediately to Mr. Pandey who is going to welcome us on behalf of the Director General of FAO.

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* Chairman of the Organizing Committee

WELCOME

Mr. SHIVAJI PANDEY*

Mr Chairman,
Honorable Ministers,
Dr M. S. Swaminathan, UNESCO Chair in Ecotechnology and Father of the Indian Green Revolution,
Distinguished Delegates,
Ladies and Gentlemen,

It is a great pleasure for me to welcome you to this important policy forum on "Responding to the Challenges of a Changing World: The Role of New Plant Varieties and High-Quality Seed in Agriculture". This policy dialogue on seed is opportune as it is taking place in the wake of the forceful declaration of the G8 summit for stronger support for agriculture and just two months before the World Summit of Heads of State and Government on Food Security, November 16-18, 2009 in Rome. In addition, we are mindful of the fact that the climate change debate and its implications on food security will take place in Copenhagen in December 2009.

Distinguished guests, I would like to share with you FAO's views on how to address the situation of food insecurity in a changing world.

We are in precarious times characterized by a worsening global food situation with the following consequences:

- The number of people suffering from chronic hunger in the world topping one billion.
- 100 million more people are being pushed into chronic hunger and poverty.
- Reducing per capita agricultural land as a result of population increase and vastly expanding urbanization.
- Declining crop productivity growth rates worldwide.
- A food price crisis that has raised the alarm among many governments, the UN and other national and international organizations.

Traditionally, the seed sector has played a primary role in increasing food production. For example, during the last 60 years, wheat yields have risen from 2.5 tons to 6 tons/hectare. However, such gains in global agricultural productivity have not influenced the crop yield in many developing countries, particularly Africa, where yields are still very low. On average, nearly 90 per cent of cereal farmers in developed countries use improved seeds, while only 5 to 10 per cent of farmers in the developing countries of Africa and Latin America buy and use improved seed. To illustrate the disparity in investment in the seed industries of developed and developing countries, we need only to note that of the nearly 36.5 billion US dollar global seed market, Africa accounts for only 1.1 billion US dollars and Central and South America accounts for 3.5 billion US dollars.

The underlying cause of this tragic situation is the neglect of agricultural investment in developing countries. Official Development Assistance (ODA) going to agriculture has fallen drastically and international aid to farming in poor countries slumped from 17 per cent of total ODA in 1980 to 4 per cent in 2006. Developing countries also did not increase their own investment in agriculture; instead they reduced it.

In the 1970s, the ODA devoted to agriculture helped develop irrigation systems, storage facilities, rural roads, seed multiplication centers and fertilizer and animal feed plants. With countries also allocating a significant share of their national budgets to farming, those investments saved the world from looming famine in Asia and Latin America. Donors and recipient countries must return to those levels of investment in agriculture, as a minimum.

* FAO, Director, Plant Production and Protection Division, Agriculture and Consumer Protection Department

Feeding the hungry today and roughly doubling food production for a world population projected to grow to over nine billion by 2050 will require political will for strengthening institutions involved in agriculture, including the seed sector.

In an effort to reverse these present trends, the Member countries of FAO have adopted sustainable intensification of crop production as one of its strategic objectives. This approach requires the integration and harmonization of all appropriate crop production policies and practices for increasing crop productivity in a sustainable manner to meet key millennium development goals of reducing hunger and preserving the environment.

FAO has called for the November Summit to help reverse the downward trend of investment in agriculture. The objectives of the Summit are to:

- Reach a consensus on eradicating hunger from the face of the earth by 2025.
- Put in place a more coherent and efficient system of governance of global food security, with a high-level intergovernmental process of decision-making, a solid scientific and technical basis more inclusive of different actors.
- Provide farmers in both developed and developing countries with an income comparable to that earned by their fellow citizens in the secondary and tertiary sectors through support to agriculture that does not distort markets.
- Boost development aid and reverse agriculture's share of ODA to 17 per cent.
- Adopt a mechanism for early reaction to food crises on the model of the early warning systems which proved very effective in 2007.

Despite some recovery of stock levels of cereals in 2007 and 2008 from the extremely low levels they had fallen to, 31 countries - of which 20 are in Africa - are in a situation of crisis requiring emergency assistance. As an emergency measure, FAO, through its Initiative on Soaring Food Prices (ISFP) has mobilized 380 million US dollars through 194 projects to provide improved seed and fertilizer to vulnerable agricultural households to increase their production in 102 countries. Of this, 286 million US dollars for 25 countries is from the EU Food Facility, and 37.1 million US dollars from FAO (TCP) for 74 countries. An additional 19.3 million US dollars is from the UN Central Emergency Response Fund. But there is a need for more medium- and long-term action to prevent a recurrence of this situation.

The present crisis may be a warning about the fragile status of global agriculture and for the need to accelerate investment in agriculture at all levels to prevent future food-price shocks. In particular, there is a need to strengthen national seed systems to make them more resilient. Also, there is a need for a strategic approach along with the participation of public and private sectors, community-based organizations, an enabling environment, resources, and a long-term perspective so that the seed industry can continue to play a key role in increasing food production.

How will governments respond to these challenges?

Primarily, there should be adequate investment in agriculture from both domestic and external sources. Such investment should consider, among other things, the development of a seed system capable of delivering the benefits of plant breeding to farmers, regardless of their scale of operation. To stimulate this line of action, FAO's role includes assisting Member countries to analyze their agricultural sector and develop bankable projects to bridge gaps. A case in point is FAO's assistance to the African Union to formulate the African Seed and Biotechnology Programme (ASBP), a continent-wide seed development initiative, in which partners will collaborate to advance seed development in Africa. In addition, FAO has facilitated the development of regional seed associations like the Asia and Pacific Seed Association (APSA) and the ECO Seed Association (ECOSA) in Central Asia and the Caucasus.

Secondly, governments should develop appropriate policies and investment – a friendly legal and regulatory framework to facilitate private sector investment in the seed and agro-industries. The synergy between the public and private sector must be harnessed to achieve this goal.

And, last but not least, the increasing pressure from climate change is likely to aggravate the difficult situation already faced by resource-poor farming communities. FAO proposes to lead a global initiative in cooperation with our international partners to elucidate the contribution of efficient seed systems in climate change adaptation.

Ladies and gentlemen, FAO is committed to the fight against hunger and poverty and will do what it can to help achieve the universal goal of hunger eradication in a sustainable way. FAO recognizes the important role the seed sector must play in this fight.

Thank you for your kind attention.

WELCOME ADDRESS

Mr. FRANCESCO BONGIOVANNI*

The Italian Seed Trade and the Importance of Breeding New Varieties

It is difficult to measure the entirety of the seed trade in Italy, because of the high number of steps in the chain of production, the resulting business income and the total surplus value (added value). Annual trade analyses performed by INEA, on the basis of ISTAT statistical data, give us a monetary estimate of seeds when they are employed for intermediary use.

According to the most recent financial statistics of 2006, the Italian seed trade appears to be stable if it is compared to the evolution of other agricultural sectors at current prices. In fact, during the decade from 1995 to 2006, the seed price more than doubled, rising from 997 million euros to more than one billion euros. However, the quota of this sector on intermediary uses decreased from 6.3 per cent in 1995-96 to 5.9 per cent in 2005-2006. This denotes that seed utilization is generally steady in respect to intermediary uses.

About 300 seed companies of variable dimensions work on national territory and produce agricultural species, while about 100 companies produce vegetable species. The number of farmers working in seed propagation is 15,000. The area aimed at seed propagation is 230,000 hectares, with a seed production of 612,000 tons (2008) which put Italy among the EU's top producers. The highest level of seed production was detected in durum wheat (91,000 hectares) and rice (12,000 hectares), followed by other cereals (40,000 hectares), forage species (30,000 hectares), maize (6,000 hectares), vegetables (10,000 hectares) and beet (4,000 hectares).

In the context of quality, it is worth noting that the procedure for acceptance is different in the cases of agricultural species and vegetable species. In addition to the requirements of distinctness, uniformity and stability, agricultural species must be of satisfactory value for cultivation and use.

In the past, the concept of value for cultivation and use of a certain variety included only its productivity. Recently, the qualitative characteristics linked to the destination of use were added to this concept. In other words, even if productivity is one of the most important characteristics in evaluating a new variety, it must be related to that of a known variety with a similar destination of use and not to the average productivity of the species.

In addition, with regard to quality and threshold in GMO products, in the Agriculture Ministry we think it is necessary to consider that in the context of all production processes seed is not a final product but a raw material. For these reasons, in the case of seed it is difficult to provide for a labeling threshold of the adventitious and technically unavoidable presence of GMO. The use of GMO seed necessarily causes its adventitious presence in subsequent products (raw material, food and feed, intermediate seed products). Consequently, the threshold of presence of GMO in seed should coincide with the limit of detection of the method used for GMO analyses.

Concluding, the weak spot in Italian seed chain production is the small number of new selected varieties, in other words, lack of innovation.

The fragmentation of the seed system has not allowed the original breeding activity to be transferred from the public sector, where it was born and developed, to the private sector.

It is desirable that an extension service be developed in Italy as in the US, working side-by-side with researchers and able to suggest and stimulate the realization of useful innovation, to individuate

* Director, Seed Office, Department of Economic and Rural Development, Ministry of Agricultural Food and Forestry Policies

adapted areas of cultivation, to make every step in production (from breeding of varieties to packing and marketing) efficient.

It is necessary to find a high synergy between public and private research in Italy. The former could be concerned with basic issues, the latter with the practical application.

In this context, public research could be financed by the royalty proceeds on certified seed or by a taxation system similar to the French one where 0.50 euro per ton of marketed product is collected.

Conlusion

Therefore, the main priorities of the seed trade are as follows:

- private and public sectors have to improve collaboration in research and in production;
- it is necessary to individuate new objectives for research, according to market trends and needs;
- national authorities have constantly to play a role in controlling the seed trade;
- quality, conservation of genetic resources and breeding of new varieties must take on a strategic significance.

KEYNOTE SPEECH

Prof. M.S. SWAMINATHAN*

Plant Breeding for an Evergreen Revolution and for Meeting the Challenge of Feeding a Growing Population in an Era of Climate Change

Mr. Bernard Le Buanec,
Members of the Podium,
Distinguished Participants,

I feel very privileged to have been asked to share some thoughts and some forecasts relating to plant breeding for an evergreen revolution in an era of climate change. I will show you a few examples of what needs to be done and also share my own views on what the priorities have to be in the coming 10 years or so if we are to meet the new challenges to which Mr. Shivaji Pandey, FAO and Mr. Francesco Bongiovanni of the Ministry of Agricultural Policy, Food and Forestry of Italy have both drawn attention.

First of all, I want to pay a tribute to all of you here; those who represent the seed industry and seed research. People do not realize the enormous change which breeding has brought about in crops in the last 10,000 years. Women, particularly, have contributed, because women in rural areas, the centers of life, have been in charge of post-harvest technology. For example, in the case of hybrid corn and maize, we have come from teosinte to maize and, in the case of wheat, from agropyron and aegilops to modern bread wheat. This can be compared to the transformation of a tiny neolithic pony into the modern racehorse. So I would like to congratulate you on the changes which you have brought about.

Incidentally, the expression "green revolution"' was coined by Mr. William Gaud from the US in 1968 and I would say it is used in the context of higher production and productivity improvement. The DG of the FAO has said: "Land is a shrinking resource for agriculture, therefore what we need is more productivity per unit of land and per unit of water" – that's what we need in the future. The green revolution in modern genetics started with hybrid corn in Iowa in the US. The Pioneer Company played a very important role with Henry Wallace and others. They encouraged the use of hybrid maize to make the first quantum leap in terms of productivity using hybrid vigor.

Then, of course, the modern term "green revolution" is related to the revolution in wheat and rice. There is a very important pedigree in the case of wheat, which has changed the world: Japanese scientists, led by Dr. Gonziro Inazuka in 1935, identified the Norin 10 gene, which meant short plants, but very long panicles. In other words, the pleiotropic effect between height and panicle productivity was completely de-linked. We also have many varieties of wheat which are short, but they also have very short panicles. Here the link was broken. There were two major streams of research using Norin 10 after World War II. One was in Washington State, where Dr. Orville Vogel and his colleagues developed outstanding dwarf winter wheat, one of the first of which was Gaines. It still, I think, holds a world record in wheat yield – 14 to 15 tons per hectare. The other was by Norman Borlaug*, (we should all pray for him because he is not very well now): he and his colleagues in Mexico started on spring wheats. Borlaug did something else; he not only tried to put in the short variety stature, the Norin 10 genes, but he also got rid of thermo-sensitivity in terms of flowering, phyto- and thermo-sensitivity, by starting what is called shuttle breeding. Shuttle breeding under two very diverse conditions – one long day followed by one short day - with the result that he was able to get rid of genes for photo- and thermo-sensitivity. This is why Norman Borlaug's initial Mexican strains, Lerma Roja 64 A, Sonora 64, Mayo 64 etc., became more popular in the developing world because we cannot grow winter wheat; we can only grow spring wheat. So these two strains, one on winter wheat, the other on spring wheat, practically changed the whole history of wheat in the world.

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Now people talk about the green revolution in Africa; I have heard Mr. Kofi Anan talking about Africa's green revolution. But unless you identify why a green revolution occurred, we can go on talking and nothing will happen. At least in the Indian context, four very important ingredients were essential. First is technology: technology is the prime mover of change. We had varieties which could yield five, six, seven tons which attracted the attention of farmers because from one ton to six tons is a very substantial step, not only in terms of technology in breeding, but also in agronomic practices. Then the services, which are needed to take the technology to small and medium farmers: in most developing countries in Africa and Asia, over 80 per cent of farmers have barely one hectare or less.. Therefore, the services which are needed, particularly seed production and distribution become important. Insurance, credit, fertilizers and irrigation are also important. Then the public policies: this is what is lacking in many countries where people want to have a green revolution but nothing happens. Because you can demonstrate this in the farmer's field – hybrid corn gives you a much higher yield, but it doesn't spread; if the farmers grow more, they will suffer because the prices will crash.

Assured and remunerative markets are the prime mover of farmers' enthusiasm; without their enthusiasm, nothing will happen. They are the people who are producing food, you and I are helpers, we are friends and philosophers, but the actual work is done by the farmers – in sun and rain they work: agriculture is the most risky profession in the world. In my country now we have drought in many areas, farmers have lost their seed, the first sowing. Now in Kenya, there is a very serious drought in many places. So many people do not realize that farming is the most risky profession in the world. This is why public policies which can ensure a stable and remunerative market are imperative. You can go on talking about green revolution for Africa, nothing will happen unless you put all the ingredients together – above all motivate the farmers. They should become enthusiastic. In other words, your attitude should be from patronage to partnership. Most of the programs are designed on a patronage principle and unless you change your mindset from patronage to partnership – without the people there, nothing will happen.

In 1968, Mr. William Guad coined the term "green revolution". Within a few years the non-governmental movement, particularly environmentalists, loudly criticized the green revolution. They felt it served company-oriented technology in the sense of requiring more fertilizer, more pesticides, etc. This was the origin of concerns about new technologies from the environmental point of view. It started with Rachel Carson's famous book Silent Spring in 1962, where she said the eutrophication of lakes, the excessive use of DDT, the long-lasting residual toxicity of pesticides ought to be controlled. That is why from that time onwards there was concern. To allay this problem, I coined the term about 30 years ago "evergreen revolution". I defined the evergreen revolution as "the enhancement of productivity in perpetuity without associated ecological harm". In other words, you have to mainstream ecology in technological development and dissemination.

I was happy when the Crop Science Society of America, for their 50th Anniversary, chose the theme "From the Green to the Ever-Green Revolution". Those of you who are interested in ensuring that whatever we introduce as technologies are environmentally sustainable – sustainable in the long-term, not only for short-term gains should read the proceedings of that meeting. They asked me to give a lecture on "The transition from the Green to the Ever-Green Revolution". It has a number of steps, but briefly, the green revolution as coined in the Asian context was a commodity-centered approach: rice, wheat, corn, pearl millet, etc.; many crops were concerned. It involved a change in plant architecture, in harvest index, that is the translocation of photosynthates to the grain. Then the change in the physiological rhythm – I have explained to you what Norman Borlaug did by means of shuttle breeding.

The evergreen revolution, increasing productivity and perpetuity without associated ecological harm, can have two major routes: one is organic farming. Organic agriculture is now gaining more and more because, in the Western world, health foods have become very important to people. Therefore, they are willing to pay a higher price for organic products; organic stores are opening up. The other route is green agriculture. Green agriculture is also environmentally sound, but on the other hand, it depends on integrated pest management, integrated nutrient supply. In conservation farming, which is now given very high priority in the US under the US Farm Bill. Now, if farm ecology and economics go wrong, nothing else will go right: in farming, ecology and economics are basic. Some people think that organic farming means going back to the past and then we will have only starvation. What people have to realize is that organic agriculture needs more research support than even chemical farming.

I have shown you what biotechnology has to do for sustainable organic agriculture. In the case of the International Federation of Organic Agriculture Movement (FOAM) they have said that no genetically modified crop can be included for certification in organic agriculture. But marker-assisted selection they have accepted; marker-assisted selection is possible for organic farming, but genetically modified varieties and recombinant DNA technology cannot be used. Since we all require plant health, in the case of organic farming, unless you have broad genetic resistance, you will have to use a lot of pesticides. The answer is bio-pesticides; New improved ways of keeping, processing and transport of animal products are needed, because in many developing countries, crop and livestock is are part of an integrated farming system. In my own country, mixed farming is a way of life as well as a means of livelihood. Mixed farming involving crops and animals, mostly ruminants such as buffalo or cows, also sheep and goats; poultry, is now also becoming important.

So in the case of soil health, there are two important requirements for organic farming: firstly, soil health enhancement – we are taking out, we need to put back – secondly, plant protection: soil health can be enhanced by bio-fertilizers, stem nodulating, green manure. If you are interested in breeding and seed production for organic farmers, or even if not, we have to intensify our work on nitrogen-fixing plants. Fertilizer trees and fertilizer shrubs must become an important part of breeding and seed production. For example, in the case of soil fertility enhancement, Sebania rostrata from Senegal is a very good plant. Now it is also stem nodulating. We have developed phyto-insensitive varieties of the Sebania rostrata; you can fix it in crop rotation; you can keep it going in 40 to 50 days. Breeding of this kind of a whole series of nitrogen-fixing leguminous and nitrogen-fixing trees is now common thanks to the work of the World Agroforestry Centre (ICRAF) in Nairobi. They have been trying in the Sahel and many other parts of Africa to identify these nitrogen-fixing trees. One of the best trees is Faidherbia albida. It adds 300 kilograms of complete fertilizer and 250 kilograms of lime to the soil. In a number of experiments it shows that where you are going to grow sorghum or any other crop without any fertilizer, Faidherbia and other kinds of fertilizer trees can make that a success. So my appeal to some of you here, particularly those working in developing countries, is to focus on those objectives. In my country 60 per cent of the arable area is rain-fed, but this year we had drought. The farmers affected know about fertilizers, but they can't risk crop failure. African farmers don't put in more that six to seven kilograms – it is not that they don't know the value of the fertilizer, but they can't take the risk as there is no proper insurance. In India, for example, we are starting a one billion tree program of nitrogen-fixing trees as part of our climate-change mitigation program. The carbon trading and the carbon sequestration give us a double advantage; you sequester carbon on the one hand and fix a lot of nitrogen and nutrients in the soil – we want a win-win situation both for the climate and the soil.

Now I am trying to underline the need for all of us to favor some new pathways of breeding.

Recently in Aquila, not far from Rome, it was concluded that we can live with an increase of about 2o centigrade. That was the main conclusion, although there are scientists who feel that at the current rate of emission, we will have an increase of at least 4o centigrade with disastrous consequences for most of the developing tropical and subtropical countries. Addressing the World Climate Conference in 1989 in Geneva, the World Meteorological Organization (WMO) asked me to speak on "Climate change and agriculture". At the previous Conference in 1979, I was asked to speak on "Climate and agriculture"; in 10 years they had changed the title to "Climate change and agriculture". There I presented data to show that with an increase in temperature of 2o centigrade, rice yields would decrease by 0.75 tons per hectare. In the whole of North India, wheat is highly sensitive to night temperatures. If the night temperatures are warm, then it starts developing fairly quickly and yield goes down by nearly half a ton, etc. Therefore, there are quite a few of us here from tropical and sub-tropical countries who should analyze in terms of plant breeding and seed selection, the impact of an increase of 2o centigrade. Let us take the 2o higher temperature now – what kind of temperature tolerances are required? This is important if you are breeding higher mean temperature. Again, before modern industrial agriculture arrived, local people depended upon a whole variety of crops; they had a whole series of crops, both for health and food security; medicinal plants for health. Indonesia, for example, had a very large number of excellent plants and varieties, but gradually, from

FAO data we see that we now depend upon 20 crops or so for the whole world food security system: rice, wheat, corn, soybean. In an era of climate change, we must again broaden the food security basket and include what we call orphan crops. The US National Academy of Sciences has rendered a very valuable service by publishing books on the lost crops of the Incas, the lost crops of Africa. There are two or three volumes by Noel Vietmeyer on the amount of loss in Africa. Many of them are very valuable for coping with micro-nutrient deficiencies, particularly what we call "hidden hunger". Hidden hunger can be worked on through appropriate horticultural remedies for a nutritional malady. Now breeders like you would analyze: this is a nutritional malady so what is the remedy, using appropriate varieties and horticulture? Since Mr. Le Buanec asked me to talk on food and nutrition security, I am talking about areas which are important.

Then there is much more as I have said. For health foods, there is a great deal of interest in all the ancient traditional wisdom in relation to medicinal plants – for example, the medicinal rice Navara, which is very popular in indigenous Ayurvedic health systems in India. It fetches a premium price and there are a whole series of medicinal and aromatic rices. You see the lost crops of Africa; you will find a lot of plants with medicinal properties which have also been lost.

How do we really work with local communities? Apart from advanced breeding and biotechnology, participatory breeding and anticipatory breeding can help to look at the emergent challenges, particularly climate change. Participatory breeding with farm families contributes to ensuring that you have some varietal diversity. In other words, if you function as a pre-breeding center and work with farmers on participatory breeding, then you can have a large number of varieties so that you don't put all your eggs in one basket. If some new disease comes along, if you have homogeneity, genetic homogeneity, might enhance genetic vulnerability to pests and diseases. For example, we have been working with tribal families in a place called Koraput. The leader of that group, a lady, went to Johannesburg to receive the Equator Initiative Award for the work she and her group had done in participatory breeding which has now led to the birth of a new variety called Kalinga Kalajeera. Bangladesh also grows Kalajeera, which is a very high-yielding variety developed by participatory breeding; the demand for it has grown and it obtains a premium price in the market. You can immediately uplift the economic status of these women and those people here if you do work of this kind.

Then there are crops which are vanishing; they are also becoming important in an era of climate change. This slide shows people who have difficulties in walking. There is a neurotoxin in lathyrus. Lathyrus is one of those legumes which used to be very popular in dry areas of much of the central part of India. It is eaten widely during periods of drought since it is the only crop that gives some yield. If the population's intake exceeds a certain threshold they develop health problems. Now scientists have tried to remove those neurotoxins. You can do this in different ways; by mutation breeding, by somoclonal variation which as you know comes from tissue culture and micro-propagation. In other words, I am asking you, depending on the countries where you work, to look at the crops which offer a particular potential to solve problems. In Europe, long ago for example, the original lupin, through successful breeding, was replaced with a sub-specie lupin which did not contain cyanide.

Another area of great concern to Asia, South Asia in particular, is the increase in flooding. I am not talking about Turkey which has had very serious flooding in the last few days, but floods may become more common. The Himalayan floods this year and last affected what we consider North India, because the snow is melting earlier, the glaciers are receding and therefore you have more frequent floods. You have to prepare. One crop which can be an important management crop, a climate management crop, is rice. The reason is that rice grows under a wide range of conditions in India and from Kanyakumari to Kashmir. There are over 150,000 strains, landraces of rice, of which 100,000 are in the gene bank of the International Rice Research Institute (IRRI) in the Philippines and are increasingly important. You have plants which can withstand low water supply. New technologies of water management imply a further reduced water requirement by 50 per cent in the case of rice: the opposite is elongation. More recently, in the publication Nature, there was a very detailed paper by Moto Ashikari and his colleagues in Japan. They have identified the genes which are responsible for the elongation of rice with flood water. They identified response factors, which they called "Snorkel 1", "Snorkel 2"; they also know the number of genes that are involved. It is important that now we identify potentially flood-prone areas. We can also transfer "Snorkel" by genetic engineering to other crops. Once we know the gene that is responsible for this factor, we can easily transfer it.

The other important crop where new approaches are needed is the potato. In India, we grow more potatoes than in the whole of Latin America, its ancestral home and we grow more than 30 million tons. The reason this has been possible is because we can produce potato seeds by planting the tubers in the Indian plains. Formerly we had to go to high ground or to Nepal to get the seed, now we can produce it because scientists have identified the season when there are no aphids to transmit the viruses. But with a rise of 2o centigrade, that season will disappear. How then do I manage my potato crop? It will have to be done only through seed. TPS (True Potato Seed) breeding today has become very international – the International Potato Center and others have been working on it. Bangladesh has a number of strains of TPS. For those of you who are interested in potatoes, please develop good TPS varieties that can be grown.

Then what about all the people who are going to suffer from the rise in sea levels? If Mr. Le Buanec had invited the President of the Maldives he would give you a very good lecture on the rise in sea levels and how his country will disappear under the waves as a result. It is not just a hypothetical concern – the rise in sea levels is going to happen. Now what do you do? You can't wait for it to happen, you will be able to do nothing then, but now we can do anticipatory work. Nature has provided us with the toolbox. In my country, Mahatma Gandhi said: "Nature provides for everyone's need, but not for everyone's greed". Nature provides halophytes, xerophytes, all kinds of plants. Halophytic plants like mangroves – wonderful plants – we call the bio-shield. We saw this during the tsunami in 2004; where there was a good mangrove plantation it acted as a breaker. We can now develop a number of varieties of mangroves, another advantage being that these plants also provide genes for salt tolerance (sea-water tolerance). Now my young colleagues are all in the final stages of work started in 1990 in transferring genes from mangroves for sea-water tolerance to rice and other crops. We have excellent salt-tolerant varieties in the field and are going to start trials as soon as the regulatory mechanism gives permission. They are all very good, economically superior varieties now containing genes for sea-water tolerance.

Similarly in the case of drought – the other problem. Increasing drought; increasing floods; rising sea levels; different temperatures, these are problems we have to cope with. In this case, nature again has provided wonderful crops. For example, Prosopis juliflora is very hardy – it can be a weed, it can be an asset – it depends on how you deal with it. It has provided genes from which my young colleagues have identified a number of factors as being relevant for drought resistance.

So, ladies and gentlemen, I think there are a series of opportunities here. In India there is talk about genetically modified crops. The only one which we have so far officially released is Bt cotton. We have a number of breeders in India in the private sector who have taken the lead in developing varieties of genetically modified crops wherever necessary; you don't genetically modify where it is not necessary. If I can find other genes for sea-water tolerance, I might not use mangroves. But I find mangroves are already growing, thriving in those conditions and therefore I take the genes out and insert them. It is important to adopt only those tools that can take you to your desired goal, speedily and safely.

In India, cotton is a very important crop; for example, cotton provides the highest number of jobs. Our problem is jobs, livelihoods. You can have food in the market, but people don't have the money. Therefore, livelihood becomes important. I was looking at the 1950s onwards, the last 50 to 60 years which I have lived through. What kind of changes have we been able to bring about, through breeding and seed selection and conventional breeding, starting from early disease-resistance, then fiber quality, on which we concentrated in the 1960s? We wanted to have the same quality as Egyptian cotton. So we developed varieties such as Sujata, a very fine quality in terms of the long staple. Then came the Pyrethroid era; synthetic Pyrethroid. But as you see, from 2000 onwards, there was a very steep rise in productivity, and not only in production. Last season showed a slight drop because of the extensive drought. But it has shown a dramatic increase, like the green revolution in wheat and rice, where suddenly production rose. Most of the area now is under Bt cotton. Our public sector institutions have a responsibility also to develop varieties, not only hybrids. The private sector essentially develops hybrids, but the public sector, for example, our Cotton Institute at Nagpur, developed the Bikaneri Nerma which is a farmer's variety with a very high resistance to bollworm and the Bikaneri Nerma Bt strain is doing very well. It does well under rain-fed farming. It requires low input agriculture and is less risky. At the same time, the farmer can keep his own seeds because in our Plant Variety Protection and Farmers' Rights Act, farmers have a plant-back right, but that is, of course, valid only in non-hybrid varieties. A hybrid you cannot plant back, you have to purchase the seed every year.

Now, there has been a lot of emphasis on cooking quality, as people become more sophisticated in their requirements through increasing urbanization. There is the basmati rice of Pakistan and India which is a very important area for export purposes. The recently introduced Pusa 1121 has created enormous interest because of its very fine quality. Farmers now use in on 75 per cent of their land. Very high productivity comes with high quality. So quality has become important for the progression of the transfer of genes to IRRI varieties. IR64, IR20: it is always important for a gene to be transferred to the best agronomic base. These varieties have received the gene from transgenic high-iron rice containing the ferritin gene. This gene, from mangroves, again by genetically combining, gives a very high iron content. According to FAO, anemia affects over two billion people, mostly pregnant women and, therefore, iron rich rice or staples can make a big difference and now you have very good varieties. The Consultative Group on International Agricultural Research (CGIAR) has a bio-fortification challenge program in seven crops: bean, cassava, maize, pearl millet, rice, sweet potato and wheat. They also have a time target – this is partly supported by the Bill and Melinda Gates Foundation "Harvest Plus" program. In my own center, we work on the ferritin gene – transfer of iron to rice and other crops. Now this is a well-coordinated program, a challenge, with a number of countries and institutions involved and the best available technologies.

As mentioned earlier by the representative of the Italian Ministry of Agriculture, it is important to have regulatory policies. Every country has to have a national biotechnology regulatory policy. We have, in India, at the moment a lot of dissatisfaction among the non-governmental organizations, with the existing procedures, so the government has come forward with an Act of Parliament, which provides for an autonomous professional body which will be purely science-based and which will be a national biotechnology regulatory authority. The bottom line for national agricultural biotechnology policy is the economic well-being of the farm family – that is number one. What is the purpose of this? National food security, health security of the consumer, bio-security of agriculture – these are becoming exceedingly important. Increasingly, H1N1, H5N1, SARS and also mad-cow disease are becoming additional threats. Today I saw a new kind of influence that is becoming problematic; bio-security issues have become major problems. The protection of the environment and trade security are of great relevance. The European Community does not allow any kind of genetically modified rice. So if I put genetically modified basmati on the market, it would kill my exports because people wouldn't buy it.

What is important for all of you under your corporate social responsibility? I think you should give high priority to conservation of genetic material. I spoke earlier of the orphan crops, knowledge dying out. We have to start at the farm level, on-farm conservation of the landraces. The 150,000 strains of rice would not have existed but for the fact that farmers had conserved landraces. So, too, on-farm conservation and national gene banks. We must also acknowledge the role of the Government of Norway and the Crop Biodiversity Trust which is located here and headed by Cary Fowler from FAO as they have done a good job with the global seed vault at Svalbard in the Arctic for what I call "conservation continuum". For those who are interested in this, you can read my editorial in Science (July 31 issue). You'll see that from the field, from the farmers' field, to the global seed vault, we must have effective conservation of genetic resources.

We have not got this for animals as unfortunately, animal breeds are vanishing. Crop seeds are somewhat more protected, so in the case of animals, breeds must also be saved for posterity. There are some very hardy breeds of animals in the Rajasthan Canal area which are now disappearing and it is important also to conserve them in a warming climate. We must also promote community conservation, the field gene bank, the seed bank. This year the first crop was lost in most parts of India. Rains came on time, then for a month there was no rain at all, so whatever had been sown was lost and, as a result, farmers didn't have seed to sow again. In other words, these community seed banks and grain banks are particularly important in all parts of Africa and Asia. There needs to be seed banks and grain banks, water harvesting and water banks so that you can give crops life-saving irrigation when you have access to water.

Finally, let me conclude by saying as a tribute to you; you all know the saying that we reap what we sow. Good seed is a starting point for a good crop. Now what are the major requirements? I consulted my colleague, Dr. Niebur, who spoke about progress in plant breeding. However seed and seed quality do not receive adequate attention. There is a large gap between plant breeding work and field application. Therefore, what is called translational research is required. For example, we have given about 20 million US dollars to ICRISAT, Hyderabad, purely for translational research – converting biotechnology innovations into field products. Translational research, the delivery system, the extension system; these are often weak. Today, there is much progress in plant breeding; however, seeds and seed quality are not receiving adequate funds. We need to invest in improving seed quality. As I mentioned earlier; progress in spreading good quality seed is required. However, there is another problem: the rising price of grain legumes. In my country, for chick peas and pigeon peas, prices are rising. Those crops are sources of protein for most vegetarians. Today they are not able to afford to buy them, because the good seed is not available. So in those cases we must promote seed villages in local communities. Women, particularly, are forming what we call self-help groups. Women sell crops for seed production and they are exceedingly good. Even cotton is included. I forgot to mention that when Dr C T Patel from Gujarat developed a cotton hybrid for the first time in 1970, many people asked how he was going to produce seeds by hand emasculation and pollination. The work was organized with women, tribal women, and they produce excellent quality seed.

So I think it is important to have more and more community farmer-managed seed systems which can derive original material from what is called the private/public partnership. I call a farmer-company a private/private partnership, because farming is the largest private sector enterprise. In my country, the land is individually owned by 150 million families. We had an archaic rule of requisitioning land and that led to tremendous protests from farmers, with the result that today no democratically elected government in India will take land from farmers. In other words, there are 150 million decision-makers for farmers. These have to grow and we must use farmer-managed seed systems and involve them much more.

Then you talk about biotechnology and the refuge. In the early days of Bt cotton, the farmer asked: what is the refuge. Why does the company give me the old seed, the old variety? There was not enough genetic knowledge. We have now started, with the Department of Biotechnology of the Government of India, a national movement in schools called DNA clubs or genome clubs. It is a very large genetic literacy movement, because in the future you are going to depend more and more on new products coming from modern biotechnology, which has opened up new horizons in terms of transfer of genes and it has to be used responsibly. But then people have to be prepared for it, to know the pros and cons; the genetic literacy movement. This is why we are starting first with the DNA clubs in schools. In this way we are moving into a new technological era, as we were doing at the time of your previous Conference 10 years ago in Cambridge.

The great difference between Cambridge and now is that more biotechnology has come in and therefore caused more controversy. The greater the power of science, the greater will be the need for the ethical dimension, so we should not be surprised. There is controversy. If you have got enormous power in using science, ethics must guide your use. So the ethical responsibility of science matters and I am sure that when Bernard Le Buanec organizes the next Congress, maybe five and not 10 years from now, you will see an enormous increase of recombinant DNA work. I don't know whether I will be alive. But I expect an enormous explosion of knowledge in using fertilizer plants, fertilizer trees, another method of enriching the soil and sequestering carbon – a win/win situation. I would like to see enormous progress in terms of anticipatory and participatory research with farming families to meet the new challenges of climate change.

I wish you continued success in the important work you are doing to safeguard human food security, health and well being.

Discussion

ROBERT GUEI (FAO): In some countries, seed legislation does not allow farmers to manage their own seed and commercialize the seed. I would like to know your views on that.

PATRICK NGWEDIAGI (MINISTRY OF AGRICULTURE, FOOD SECURITY AND COOPERATIVES, UNITED REPUBLIC OF TANZANIA): I just wanted to get your view on what we should do in Africa. You have just told us the four components of a green revolution that took place in other parts of the world. In Africa we are now struggling to include those components and I think we are not yet there. Now you are talking of an evergreen revolution. What is your advice for us in Africa?

MICHAEL MUSCHICK (ISTA): I am still looking at your slide and it reads "seed quality is not receiving adequate attention" and I would be very interested in your concrete ideas to change this.

MOHAMED TAZI (FAO): Instead of giving emergency aid in Africa and developing countries, do you think that giving the genes instead of giving funds will be an option in the future?

PROF. SWAMINATHAN: On the question of seed legislation, farmers' seed production, I think that any legislation should look at the methods of providing good quality seed for the farmers. The bottom line is a reliable and good quality seed supply which will germinate on normal quality parameters. In my view, farmers have a very important role to play here. Companies by and large develop hybrids which have to be bought every year and the companies can ensure the quality. But then you have self-pollinated plants, local varieties which are grown. When you change from more exploitive agriculture to sustainable agriculture, you require varietal diversity, more and more local adaptation. This is why I said some kind of pre-breeding plus participative breeding with farmers is much more important, because then you don't have the risk of pest epidemics, as long as there is some varietal diversity. Therefore, I would request countries not to prohibit farmers from participating in seed production. If the farmers are working closely with companies, it is very good. In India, a lot of them are working, trying to produce seeds for the companies – contract cultivation, contract farming. But I would not discourage farmers' seed systems because I don't see, knowing some of the countries in all parts of the developing world, that purely one size will fit all. Any legislation must be encouraging – encouraging for production of good quality and adequate quantity of seeds. It should not be discouraging for the farmers. That would not be in the nation's interest. We must recognize that we all live in this world, by courtesy of the sunlight, the green plants and the farmers who grow the green plants and can make them into food. They are the real hosts – all of us are only guests on the earth. Therefore, if the role of farmers is not recognized, I think it will not be good for the country's progress, particularly where more than 80 per cent of people are farmers. Even in relation to WTO negotiations, many times the words "consumers" and "farm producers" are used. In India, for example, there are only two categories, consumers and producer/consumers: 70 per cent of producer/consumers and 30 per cent of consumers, even in urban areas. Now you have to think that more than one billion are undernourished, many of them farmers. Many of them are small to medium farmers working in non-irrigated areas and they are the producer/consumers. If you don't help them to consume more, the figures will remain stubborn. I see the FAO's figures are going up not coming down in relation to main development goals. They are authentic figures, but we must ask ourselves why it is so. In spite of all the concerns, again and again, every time the G8 or others meet, there will be promises of say 120 billion US dollars, but why is it that we are still increasing the number of people going to bed hungry, not reducing them? Time to ask hard questions.

The second question from our friend from Tanzania is very important. The whole question of the evergreen revolution and related things is a matter of common sense. It's the farmers' wisdom combined with scientific technology. Farmers have always been concerned with sustainability. That is why they selected, for example, fertilizer trees. You and I didn't select them, they were selected by farmers; fertilizer trees in Senegal were selected by farmers. Therefore, the farmers' own experience – they have experience because day in day out they work with life; they work with the sun and the rain. Therefore, I think you must be sure that the evergreen revolution is very simple: Whenever you do something, in your own world you must aim at sustainability. All of us have salaries and money and we manage that sustainably, otherwise we would become bankrupt. The same is true with land and water. Biodiversity - that word means evergreen revolution, sustainable agriculture. It is what farmers want. Otherwise they will all talk about organic farming. Again, in your country, there has to be this transition from purely patronage to partnership with farmers otherwise it won't work.

ISTA seed quality and quality literacy have become very important. Today with modern information technology, a lot of educational tools are available. We have science centers in India which try to promote quality literacy. The Chairman of the National Commission of Farmers of India recommended that on an outstanding farmers' field, where somebody is producing outstanding quality, we should put a dormitory/hostel to allow other farmers who want to take up activities to learn from him. For example, it may be for tissue culture for bananas. Farmer-to-farmer learning has high credibility for the simple reason that farmers in my country believe other farmers from an economic point of view. They don't believe the agronomists because they think they are underestimating the costs and overestimating the income. Therefore, they believe in the farmers' own economics.

Emergency help is always in terms of food aid when people are starving because they need food today, not tomorrow. But what you mean by giving genes, this is what I call pre-breeding and participative breeding with farmers. Whichever genes are important for the country, those must be made available. This is where the multilateral system of exchange in the case of IT PGRFA is important. Some methods which we have now developed at the request of FAO are to elaborate guidelines for genes for helping people to overcome the impact of climate change: genes for adaptation to climate change. In fact, that is what I pleaded in my Science editorial. This can be done and they have to be given to people who are competent to convert them into local varieties. When you face new situations, you need new responses, and I hope the forthcoming summit at FAO will indicate some measures by which to address this issue. Please remember my message – I think the green revolution will not happen unless you have affordable technology, reliable technology, low-risk technology, to provide the services by which good quality seeds are available at the right time, water, electricity, etc. You have the price mechanism – input/output pricing, so that the economics are right. In my own country, in spite of all of our talk, the National Sample Survey Organization of the Government of India took a survey of farmers: 45 per cent of those interviewed said they would like to quit farming if they had other options. In my country, 75 per cent of the population is below the age of 35: young people. How am I going to attract and retain this youth in farming if their own parents want to quit farming? That is why my last point on farmers' enthusiasm comes only if farming can give them a reasonable income.

CONCLUSIONS OF THE EXPERT FORUM

Session 1 conclusion, presented by the Chairperson, Mr. Orlando de Ponti
The role of plant breeding in meeting the multiple challenges of a fast-changing world

- Improved varieties and high quality seeds are basic requirements for productive agriculture, which is the basis of sustainable economic development in developing economies
- Through the efforts of both the public and private sectors, plant breeding has provided an enormous contribution to global agriculture (yield, resistance to biotic stresses, tolerance to abiotic stresses, harvest security, quality traits including nutritional value, etc.)
- Plant breeding has the ability to significantly contribute in solutions to several of the challenges ahead such as food security, hunger alleviation, increasing nutritional values, and higher input costs. Plant breeding and related disciplines and technologies help in mitigating the effects of population growth, climate change and other social and physical challenges
- Intellectual property protection is crucial for a sustainable contribution of plant breeding and seed supply. There are still many tools and traits in the pipeline that will prove to be very necessary for the continued supply of high quality varieties and seeds
- Apart from genetic enhancement, other technologies, e.g. quality seed production and seed treatments, contribute substantially to improved seeds, and capacity building in all these areas is urgently needed in developing countries.

Session 2 conclusion, presented by the Chairperson, Mr. Bert Visser
The importance of plant genetic resources for plant breeding; access and benefit sharing

- Plant breeding and the sustainable use and conservation of genetic resources are interdependent.
- The International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) is a unique and innovative legally binding instrument providing facilitated access to genetic material for plant breeding at the international level
- The Multilateral System (MLS) of the ITPGRFA provides a consistent Access and Benefit-sharing option for plant breeding activities
- The Standard Material Transfer Agreement (SMTA) of the ITPGRFA is a contract between the provider and the recipient that is simple to use and facilitates access to germplasm
- The involvement of the private sector in the design of Access and Benefit-sharing schemes is necessary for a well functioning Access and Benefit-sharing mechanism
- Material in the MLS is a source of genetic traits and characteristics of interest
- The full success of the ITPGRFA and its MLS will depend on local, national and regional implementation, as well as on the availability of funds at the local, national and regional level.

Session 3 conclusion, presented by the Chairperson, Mr. Doug Waterhouse
Plant Variety Protection

- The number of new varieties increased after the introduction of plant variety protection.
- Introduction of the UPOV system of plant variety protection was associated with increased breeding activity and with the encouragement of new types of breeders, such as private breeders, researchers and farmer-breeders. The introduction of PVP was also associated with the development of partnerships, including public-private cooperation.
- Introduction of plant variety protection was associated with the development of new, protected varieties that provided improvements for farmers, growers, industry and consumers, with overall economic benefits.
- One of the benefits of plant variety protection is to encourage the development of new, improved plant varieties that lead to improved competitiveness in foreign markets and to development of the rural economy.

- Membership of UPOV was associated with an increase in the number of varieties introduced by foreign breeders, particularly in the ornamental sector.
- The breeder's exemption, whereby protected plant varieties can be freely used for further plant breeding, is an important feature of the UPOV system which advances progress in plant breeding.
- Access to foreign plant varieties is an important form of technology transfer that can also lead to enhanced domestic breeding programs.

Session 4 conclusion, presented by the Chairperson, Mrs. Katalin Ertsey
The importance of quality seed in agriculture

- The session demonstrated the importance of seed quality for crop productivity and agricultural production. It has underlined, that a lack of information on seed quality could result in crop failures and has the potential to threaten food security for whole countries
- The determination of seed quality parameters requires a broad knowledge of plant and seed physiology, taxonomy and botany and requires intensive scientific studies and research
- The application of seed quality evaluations requires a detailed knowledge regarding seed production, seed marketing, seed regulations and the seed sector
- Since 1924 the International Seed Testing Association (ISTA) has been the impartial and objective platform where leading seed technologists and researchers have come together to discuss relevant scientific progress and make the necessary definitions regarding seed quality and how to measure it
- Currently in developing countries there is not an adequate seed quality assurance infrastructure with respect to seed testing and this is required to increase crop productivity and provide enhanced food security in these countries
- The evolution of seed quality determination has not reached an end point and there are interesting developments in the pipeline that take account of the changing needs of the market. These will make tests and their applications more relevant, effective, robust, quicker and cheaper
- Significant cuts in scientific research and education has reduced the possibility for young academics to acquire the necessary seed technology skills
- In the seed technology area transparency in and scientific exchange of the latest research results remain of crucial importance for continued progress
- Uncompetitive salaries for seed analysts in developed countries make a career in seed quality control unattractive for young people.

Session 5 conclusion, presented by the Chairperson, Mr. John Kedera
Facilitation of trade and market development

- Global seed market has grown rapidly in recent years and is currently estimated at about US$37bn. Europe, North America and Asia account for almost four-fifths of the global seed trade. For 2007, the international seed trade was estimated at US$ 6.4bn
- The use of international certificates for varietal certification, phytosanitary measures and laboratory testing has greatly facilitated the development of the international seed trade
- Production and marketing of certified seed of all agricultural crops is highly regulated at both the national and international level. A transparent and efficient regulatory system is crucial to ensure that farmers have access to high quality seed at a reasonable price
- The international regulatory framework consists of certification based on varietal identity and varietal purity (OECD, AOSCA), phytosanitary measures (IPPC, WTO-SPS, NPPO), plant variety protection (UPOV) and seed testing (ISTA, AOSA, etc.)
- Regional seed regulatory frameworks have been developed and harmonised to facilitate regional trade e.g. Central America, Mercosur, EAC, SADC, ECOWAS, etc. Regional standards, such as those of the EU, are closely aligned with international standards such as those of the OECD and clearly set out the registration and certification conditions for the marketing of seed
- The increasing use of harmonised international certification procedures on varietal identity and varietal purity helps to facilitate the import and export of high quality seed by assuring consumer confidence and reducing technical barriers to trade

- Good cooperation between the public and private stakeholders in developing and setting standards that are internationally acceptable has facilitated the issuing of certificates which, in turn, has contributed to the growth in trade
- Implementation of measures to prevent the introduction and spread of plant pests is critical to ensuring the development of a viable and sustainable global seed market. The International Standards for Phytosanitary Measures (ISPMs) provide useful guidance on the application of phytosanitary measures to the international seed trade.

OVERVIEW OF THE EXPERT FORUM

BERNARD LE BUANEC

Ladies and Gentlemen,

As I said during my opening address last Tuesday, we showed during the First World Seed Conference held in Cambridge in 1999 how new plant varieties and quality seed were important to meet the challenges humankind was facing to ensure environmental sustainability and food security. Today, 10 years later, those challenges persist and have even intensified with an increasing realization from all countries in the world of the need for food security in the context of climate change. The food crisis of two years ago showed that food production levels are on a knife edge and vulnerable to weather fluctuations and government policies, with a significant impact on food availability and prices worldwide.

The population continues to grow and, according to UN statistics, should grow from 6.8 billion people today to a little more than 9 billion people in 2050. The food demand will increase dramatically due to quantitative, but also qualitative needs. To meet that food demand, it is generally recognized that crop production will have to increase by more than 50 per cent over the next 20 years. The level of urbanization will reach almost 70 per cent in 2050 from around 50 per cent this year, putting more pressure on each farmer to feed the urban population. Meanwhile, the arable land area per inhabitant will continue to decrease from 0.25 hectares today to 0.15 hectares in 2050. In addition, the decision by many governments to encourage the production of third generation biofuels requres more crops to be produced. The only solution to meet those challenges, and that was said this morning by Prof. Swaminathan, is to increase significantly the productivity of each hectare of cultivated land.

In this period of concerns about food prices and food security, FAO, OECD, UPOV, ISTA and ISF considered that it was timely to organize this Second World Seed Conference with the objective of identifying the key elements necessary to ensure an enabling environment for the development of new varieties, the production of high-quality seed and their delivery to farmers.

Source ISF

You see now five maps (see Fig. above): four maps represent the members of the ISF, OECD Seed Scheme, ISTA and UPOV. In the middle you have a map from the FAO website showing the hunger map in 2005. Of course, it is not possible to make a direct link between the level of hunger and, as you see, the absence of those countries in all the seed organizations. Such a direct link would certainly be inappropriate. However that observation certainly deserves more thought, taking also into consideration other important factors.

I hope that the result of our Conference will help to answer some of the questions.

Now I am going to summarize the conclusion of each session:

Plant breeding has significantly contributed and certainly will continue to be a major contributor to increased food security whilst reducing input cost, greenhouse gas emissions and deforestation. In that way, plant breeding significantly mitigates the effect of population growth, climate change and other social and physical challenges.

The International Treaty on PGRFA is an innovative instrument that aims at providing food security through conservation, as well as facilitated access to PGRFA under its multilateral system, called MLS for Access and Benefit-sharing. The MLS represents a reservoir of genetic traits and therefore constitutes a central element for the achievement of global food security.

Intellectual property protection is crucial for a sustainable contribution to plant breeding and seed supply. An effective system of plant variety protection is a key enabler for investment in plant breeding and the development of new varieties of plants. A country's membership of UPOV is an important global signal for breeders to have the confidence to introduce their new varieties in that country, thus facilitating technology transfer.

Seed quality determination based on scientific principles before supplying the seed to farmers is an important measure for achieving successful agricultural production. The establishment and maintenance of an appropriate infrastructure on the scientific as well as the technical level in developed and developing countries are highly recommended.

Finally, the development of readable and internationally acceptable certificates for close collaboration between all stakeholders along the supply chain for varietal certification, phytosanitary measures and laboratory testing contributes substantially to strong growth in international trade and the development of seed markets.

So those, ladies and gentlemen, are the conclusions of our expert forum and I hope that it will give you food for thought for the coming months and years, but before that, food for thought for the panel discussion which we are going to have now.

Thank you for your attention.

PROVIDING AN ENABLING ENVIRONMENT

Panel discussion

PETER LATUS (FEDERAL OFFICE FOR AGRICULTURE, SWITZERLAND): I want to bring the discussion to a question that we still haven't discussed. The last two days we have heard about dying breeders, we have heard about soon-to-be-dying baby boomers, something I don't wish for since I'm one of them! I want to raise the point of the danger of the possible dying out of very successful variety listing and seed certification systems in what we call developed countries, such as Switzerland where I come from. Why do I have this concern? I have this concern because variety listing with us and EU recommendations are being seen more and more in our countries, especially in the German-speaking area, as an instrument to avoid diversification in plant production for small markets who want to increase products by adding local varieties, old varieties, old foreign varieties, or any material. For us, we have already been having this discussion for six months; it is very difficult to sell the advantage of a very successful system, variety listing certification, to the public and to the policy makers. They ask us why we want to protect farmers from themselves if they want to store uncertified material from that material. I want to ask the panel: What do you think about the challenge for all of us to enable the production, to introduce a system for the production of these "out-of-the-system" varieties and to keep the seed certification system and to respect plant protection recommendations? I think in our developed countries that will be a very important question over the next few years.

ORLANDO PONTI: To start with the first part of your question, we were also discussing yesterday that we might have a problem of succession in industry and also in the public environment in seed certification, plant variety protection, etc. Yes, there is a problem and I think worldwide we share your concerns. It is not just in developed countries, but also in developing countries. I can tell you, from my close involvement in the Netherlands, we have been trying to manage ways to get more school kids into what we think is an exciting profession. However, the problem is that, because we are innovative we like it, but it seems that it is very difficult to bring that to the understanding of those who are still at the beginning of a career. I would like to mention one thing that we did very recently and it seems to be quite effective. We have to admit, if you look at the figures every year, that over the last 10 to 15 years, the number of new students coming into agriculture in general, including plant breeding, plant protection agronomy, is extremely low. We have noticed in our country that there is a steady and stable number of new students going into biology. That is very interesting because agriculture is based on biology. So what we did this year is we organized a one-week summer school in the Netherlands, with Wageningen University, Plantum and the National Seed Association, and we invited bachelor students who were already in some way involved in biology and we communicated with them through a very active program, both academic and with excursions, saying: "Look, here is a field of industry and the environment around, that is very exciting. So you are midway in your academic training and maybe you should make a small move and move in the direction of the field of plant breeding in all its aspects." What I got back from the summer school is that it was successful, but we have to see how many of those students now make the final decision to say: "I'll go in another direction and I'll go in the direction of the plant industry". It is not easy at all, but I think we have to work very hard on it around the world because we need competent people in order to manage and to work in this important business.

BERNARD LE BUANEC: I think that the question was also on the need or not of [Value for Cultivation and Use] VCU and registration and cataloguing at national level. I would say that that is a mainly national issue rather than an international issue, so I would probably transfer that question for discussion to national level. What I can say is that you have in the world many different systems and you have systems where you have registration and VCU very strongly regulated, and you have countries where you don't have any catalogue at all. Experience shows that there is no link between the system you are implementing and the quality and success of agriculture. It is mainly a national issue, and I know countries where you have no VCU, no catalogue, with very efficient agriculture and the same with a catalogue, so there is no link there. I would suggest that you discuss that at national or regional level, but not probably in this forum.

ROLF JÖRDENS: As a representative of the International Union for the Protection of New Varieties of Plants (UPOV) here, a sui generis system of plant variety protection, it is perhaps important to note that the UPOV Convention clearly states that this system of plant variety protection is independent from market regulations. This sui generis system of plant variety protection can stand on its own and can be very successfully operated and implemented independently; it must even be implemented independently from market regulations.

WAYNE JONES (OECD): The comment came from the question on why we would want to protect farmers from themselves. If they want to use uncertified seed, let them do so. In our work with developing countries, which we often do jointly with the FAO, quite often what we find is that there are simply no functioning input markets in some of the least developed countries. It is not a question of farmers making a choice; they have no access to seed, to fertilizers, to credit. One of the first rules in terms of development that we have come across in our many years of experience in different countries, in different contexts, is that governments need to move with the private sector and also with the international agencies and develop those input markets. Otherwise there is simply no access, particularly for smallholders, to things like certified seed.

THOMAS OSBORN (FAO): I would like to reinforce what the others have said, that these systems in many developing countries need to be strengthened. But at the same time, we also need to bring up your point about what farmers are using now; we need to have greater knowledge of the traditional varieties and the varieties that farmers are using now. This is very important in terms of the conservation and use of germplasm that we will need for the future and if there are emergencies or other activities, or the need for transferring between different agricultural zones. There is also the formal sector and the formal variety registration system, but we need to know more about the informal system, so it can feed into other work and other needs for the future.

BERT VISSER (CENTRE FOR GENETIC RESOURCES, WAGENINGEN UNIVERSITY AND RESEARCH CENTRE (NETHERLANDS): My comment is on the same lines. You suggested in your question that there is a contradiction between the need or the desire for variety listing as we know it on the one hand, and requests from farmers and farming communities for more options to grow traditional varieties on the other. I do not think that there is a contradiction. Within the European Union, there has been a first attempt, I think, to combine the merits of the two systems by the introduction of new legislation which is called the EU Directive of Conservation Varieties. Although I personally think this is still not an ideal Directive, it is at least a first step in the right direction and it shows that the two systems, a variety listing for released varieties from the formal sector and more room for the maintenance of traditional varieties by farmers, can be combined.

FRANÇOIS BURGAUD (GNIS, FRANCE): This morning we were reminded, as we were now by Prof. Swaminathan, that last year the food crisis brought home to the international community once again the importance of agriculture and in the development of that agriculture, the importance of seeds. One could be led to imagine that there would be new hope for developing this sector in order to, once again, encourage development. And yet there is an important risk factor and I would be interested to hear the opinions of the panel who are heads of international organizations, on the concerns that I would like to raise. The timeframes in which governments work are not the same as those used by agriculture or the seed industry. Over the last two days we have heard many speakers say that the time for selection for the creation of new varieties is long – seed production takes time, it takes several generations and, therefore, the moment of identifying and developing a new variety suitable for the farmers and the moment that that seed is made available to the farmer generally takes several years. The programs that we have heard about over the last year, for example from the representative of FAO who spoke of the 300 million euros given by the European Community to undertake urgent seed projects, are not going to resolve the question of developing the seed sector in developing countries. So there is a real risk here in that there might be a decline in interest by the international community once again and it is more than likely that the way the money has been invested will not have served any purpose. I would like to understand whether this feeling is also shared by members of the panel and, if so, what does our panel think can be done by the international organizations represented here to help politicians understand that the timeframes of the seed industry and farmers are not the same as theirs and, secondly, that in my opinion, we should make them understand that between the poor smallholder and agricultural research, as Prof. Swaminathan said this morning, there is a whole sector, the production and commercialization of seed, that we have seen over the last two days is essential, and is very often forgotten in urgent operations and international projects. The representatives of the African Seed Trade Association reminded us several times yesterday that they had found it extremely difficult to find assistance.

BERNARD LE BUANEC: Just a quick correction and then I will ask the panel members to answer. During our discussion yesterday and the day before the term "long-term investment" was used several times and that is part of your concern. Who on the panel is willing to react on that topic?

XAVIER BEULIN: I don't want to answer this question directly because I think that it concerns the difference between investment in emergency situations and medium- and long-term investment. Representing my organization, I can tell you speaking for farmers worldwide, we are against emergency aid. Not food supply, but we are concerned about the impact that emergency aid can have on investment in agriculture, in particular in seeds. I would like to add to what François Burgaud said: how can you imagine in the southern part of the world, farmers who year after year are subject to volatility without any compensatory mechanisms, without any safety net, how can you expect them to invest in the medium to long term in the production of seeds? How can you imagine that this investment can be made? It is simply not possible. So I think that there is need to rethink the situation. I remember that last year at a Conference organized by FAO in this same hall we heard very radically opposed ideas; some governments came to say that what was important was to invest in emergency aid to deal with a crisis and other governments said that we needed to put an end to that and dedicate these resources to investment in the medium and long term and in particular investment in production factors, and of course seed is at the top of that list. I could add a third element. This raises questions for the seed companies too. Because if we don't have public/private mechanisms facilitating access to quality seeds, then it is very difficult to imagine that the stakeholders themselves can respond to the medium- to long-term difficulties in their seed production. So we need to have an intelligent combination of public policy enabling medium- to long- term investment with the private sector. Here of course we also have the will of the seed associations and companies in particular if they need to be able to meet the challenges, particularly at local level.

JOHN KEDERA: I think we have also made an assumption that the politicians understand the complexity of the issues that we deal with in seed. I believe that we need to start creating real awareness on the issues, because we make an assumption that they understand and when they make a decision, they make a decision that is based on political experience, not on the right decision that will help the seed industry or supply of seed to the farmers. So I think there is a need to create awareness.

WAYNE JONES (OECD): What is probably amazing is not the political response to the food crises, to the 1 billion plus that are now in hunger, but the fact that there have been 800 million plus in the same situation for decades and nothing has been done about it and the numbers remain the same. What happened with the food crisis, the rise in prices was just a wake-up call and I think we are very lucky that governments now see it back on a political agenda at the international level. I think there's a strong recognition that something needs to be done, but the same question that was posed is: What? What do we do and how do we do it? That is much more difficult to answer. Clearly, a large part of the food security, or insecurity, problem is poverty. The solutions lie outside agricultural development in a sense; other than making the point that many of those in poverty are also in agriculture; they are already farmers. What I think the OECD's six-point plan would be, what we have found is for those countries that have been able to make vast improvements in the reduction of hunger and poverty, they first got the basics right. They have introduced good governance and this is fundamental. Virtually nothing else can proceed until you have a reliable and transparent business environment. Then you need to take (which we saw with the green revolution) a very comprehensive approach: that is there are many factors, many of which were listed this morning, and dealing with just one of those, whether it's research or input markets, or developing the market, making sure farmers receive a return; there is a long list that was already mentioned this morning. All of those factors need to address something in order to have a successful outcome. Public goods – this is something that we think of in many of the countries that moved into a system of privatization. Many of the institutions and infrastructures which were maintained by governments in parastatals suddenly disappeared, particularly in developing countries, and they were left without the kind of input markets that the people need. That needs to be revisited. Research and development is clearly important, but what was mentioned this morning is the importance of linking international developments with local needs. In particular, in developing countries there is a need to bring this kind of research and productivity to the smallholders. I think that is what is being developed now. Last, but not least, was a point that was made by several people this morning that we have to move away from this patronage and much more into a partnership arrangement; a kind of Paris Declaration attitude that the international agencies need to work in partnership with the individual countries. I think if there is one message that we would like to give it is that you people, as already mentioned, form part of a huge industry: 6 to 7 billion US dollars in international trade. You have a serious voice in the world of agriculture and trade policy, at least you should have and I would encourage all of you to ask yourselves how are we being engaged in the policy debate and how can we do a better job of that. That is something maybe for the next Conference.

THOMAS OSBORN (FAO): FAO certainly agrees 100 per cent on the crisis: our DG raised the alarm at the end of 2007. Of course a part of that was a short-term response in productivity safety nets to help vulnerable farmers produce more food, but also, certainly on the technical side, with our partners to look at more medium- and long-term initiatives that were needed. This was followed by the food summit last year and one that will be held this year, and even the purpose of this meeting is to bring attention to the issues related to seed. Part of that was the development of the UN Comprehensive Plan of Action, that's not only FAO, but FAO working with all the other UN agencies relating to the food crisis and what really needs to be done in the short, medium and long term. The other thing I would like to mention, that Prof. Swaminathan mentioned, is that we are not just talking about seed, and where we are clear when we give our technical message is that it's about looking at inputs of seed, fertilizer, credit. It's looking at improved production systems, organization of farmers, irrigation, this kind of issue, and then the market, linking farmers with the market. If you just improve the seed without looking at the rest of the system, you are not really going to achieve your objective. The last point I would like to make is that FAO is certainly committed to working more effectively with the private sector and this has been part of our response related to the soaring food price issue. There have been a number of forums and discussions with the private sector and we certainly see the private sector seed industry as very important partners for getting the technologies, the improved varieties, which are needed throughout the world out to farmers so that they can get higher levels of production.

MICHAEL MUSCHICK (INTERNATIONAL SEED TESTING ASSOCIATION (ISTA)): My feeling is that if we are talking about a long-term strategy we also have to talk about knowledge: knowledge transfer and also communication. We need to transfer the knowledge we have in the developed world to the developing world and we need to build on the knowledge we have currently in the developed world and to strengthen it. But the real situation in fact is that we are reducing capacity; we do not have sufficient capacity in the developing world and we are reducing capacity in the developed world. So I think that this is definitely a point that we have to be aware of and we have to take into consideration.

ORLANDO DE PONTI (PRESIDENT, ISF): I would like to follow up on the issue of good governance and a transparent business environment because we have to be aware, whether we like it or not, that plant breeding is a slow process, for the simple reason that it takes generations. But there is a means of speeding it up and that is what we call shuttle breeding. If you are able in your breeding program to do one generation here another generation there, from one hot spot to another using the two hemispheres, you can speed up the program. The problem is that in many countries, if you do this, your seed sits for weeks or months at the customs. As Dr. Jördens mentions, if governments moved into good governance and an efficient and transparent business environment, there is a very simple means of speeding of up the breeding program. We cannot do it because we have to stick to those rules and, quite often, we have major problems for this type of activity. That is what I call the regulatory environment, which is very important for the breeding industry because, for good reasons, we are bound by many regulations but please make them as efficient and effective as possible.

ROLF JÖRDENS (VSG, UPOV): I think over these two days, it has become very apparent that we need to create an enabling environment for creativity. We need to have clear and simple legal systems under which creativity is encouraged. Initiatives of thousands of people, perhaps millions of people need to be activated and that is indeed the approach on plant variety protection according to the UPOV system. It is a straightforward system, which can relatively easily be transferred into a national law and, through cooperation, it is also easy to implement and thereby private initiatives and also public initiatives are encouraged. There is not very much public investment money required. We don't speak here of millions or billions of dollars; it is a relatively cost-effective approach – that is an element of good governance.

BERT VISSER (CENTRE FOR GENETIC RESOURCES, WAGENINGEN UNIVERSITY AND RESEARCH CENTRE (NETHERLANDS): On a slightly different note, one of the panelists mentioned that many of the people in poverty are farmers. I think one of the options, and I think we need a multitude of options to deal with the food crisis, is to make these farmers and these farming communities more autonomous in their food supply and in providing their food security. I think that Prof. Swaminathan rightly mentioned the enormous importance of more participatory approaches. They assume not only that there is technology transfer from developed countries to developing countries and from breeders to farmers, but also vice versa, because there is a lot of knowledge of local systems, of local situations, among the farmers that must be used, exploited. I think that if we can make farmers more autonomous in that way, by giving them better access to genetic materials, including from the private sector, by providing them with knowledge to help them to cross and select for their own purposes and for their own markets, then we will also improve the food security of the farmers. It doesn't mean that the private sector in those cases is less needed. On the contrary, because "participatory" implies that there are different parties working together and I think that is the ultimate form of public/private partnership that we need in this respect.

BERNARD LE BUANEC: I am not sure that we really have the answer to a need for long-term investment, but obviously we are all in agreement that the question will be how to convince governments to make long-term investment. Before giving the floor to your questions, I would like to make a comment regarding the importance, in terms of money, of the seed industry. It has been said that it is a large industry, a significant industry and that we have a 37 billion US dollar turnover. But that is nothing. If you compare the seed industry to the value of agriculture at the farm gate, it is 370 billion US dollars and if you compare that to the turnover of the agri-food business, it is 3700 billion dollars. So the seed industry represents 1 per cent of the turnover of the agri-food industry. We are essential, but unfortunately, we are not important enough to be able to lobby governments efficiently. That is something we have to bear in mind.

IR. HINDARWATI (DIRECTOR, CENTER FOR PLANT VARIETY PROTECTION, INDONESIA): My question is to the OECD. As I learnt from the presentation yesterday, it is important to ensure quality of seed and therefore you think the same standards are very important: the OECD Scheme is important, but membership is just for governments. I think the participation of the private sector is important to support governments in membership of the OECD. My question is: Do you have any strategy to attract governments to cooperate with the private sector to join the OECD? But I have one suggestion to add: I suggest that we have some statement to cope with the challenges of changing the world, we need acceleration of new variety generation by focusing on varieties with important traits and less input using genetic resources as a main national investment and biotechnology as tools to engineer plant breeding. Therefore, public/private partnerships achieve an acceleration of new variety generation with a win/win solution using intellectual property and plant variety protection as a tool to protect the technology used and for new varieties. That is my suggestion to add to your conclusion.

BERNARD LE BUANEC: First of all thank you for that and could you perhaps make a written proposal?

WAYNE JONES (OECD): Very briefly, before I ask my colleague, Michael Ryan to comment on OECD strategy, because the Seed Scheme does have a strategy in development. But I can't let Bernard go because he is maybe too conservative on the importance of the seed industry. Maybe the dollar figures aren't the right ones to use, but in the FAO's work that they are doing now on how to feed the world to 2050, they have held some technical and expertise sessions such as this one and in one of the reports (at least I hope I'm not misquoting FAO research), they are arguing that at least half of the expected productivity gains in the years leading up to 2050 are going to come from seeds. And that has got to be a huge hammer with which to hit politicians in terms of the importance of the seed industry and the importance of a regulatory environment that can help them move ahead. One of the comments I would like to make on your proposal is what I heard this morning from a couple of the speakers. The importance of using the full buffet of research that is out there: biotechnology, genetic transfer to decide what is best for an individual crop in an individual country. I think it would be wrong to partly close the door on any one particular avenue of research when we look at the kind of increase in production that we need over the next several decades. Could I ask Michael Ryan to make an intervention?

MICHAEL RYAN (OECD): Thank you for that question. I think the first part of the question related to governments that are not already involved in the OECD. In the OECD we have an enhanced engagement strategy at the aggregate level and Indonesia is a member of that group and that is part of the outreach work that is taking place with non-OECD members. On a more specific level, the strategic plan which I mentioned yesterday also has a component that is looking at further developing linkages with non-member countries or countries that are not yet members of the OECD Scheme. As part of this outreach work, at the 2010 Annual Meeting, we will have a special workshop that will focus specifically on the Asian region and this workshop will be held in New Zealand in March 2010. We will invite as many countries as possible from the Asian region, OECD Seed Scheme members and non-members and we will have a chance to discuss this a little bit further at the APSA meeting in November 2009 in Bangkok. On the other issue, there was a question related to the involvement of industry in the work of OECD. Yesterday, I mentioned that industry can have an influence in two ways: one is through the formal approach to government representatives and the national designated authorities. But there is also an approach where industry and companies can take part through the BIAG Committee (Business and Industry Advisory Group Committee) that meets regularly with different committees within OECD and shares concerns, information and discusses the position of the industry and also possible solutions to emerging problems in the sector. So there are a number of ways of linking the industry and the private sector with the policy work that is currently taking place in OECD.

BERNARD LE BUANEC: I will just add that also, for cooperation with industry, ISF is a permanent observer in the OECD Seed Scheme. It is extremely important for the seed industry.

JEAN-LOUIS DUVAL (JLDUVAL CONSULTING SARL, FRANCE): I would like to come back and continue a little bit on what François Burgaud raised. It will be about long-term and short-term investment, because I am in the field scene now, having been for seven years in the developing countries. I will say about long-term investment that, yes, we have heard that it is more sexy to train PhDs for our future and for creating new varieties and we need some. However, the issue will remain when the varieties are arriving from those programs, and what I have seen is, in the short term, the availability of seed is here, but it is not used. The germplasm is available but even, you know we speak about PhDs, but to do good screening just to test the variety in the field, in many places it is not done. So when the new variety arrives in 15 years, we will have to address the same issue in a certain way, and I will take the words of the remunerative market for the farmers: How can we address this issue with a more comprehensive approach where the logistics, the important aspects I have seen so much of and that when the seed company wants to develop the variety in a new country, it is obliged to give the seed free because the farmer is unable to purchase it? So the question of credit for farmers seems to me a very limiting factor. So could we ask the panel if they have the same view of these limiting factors and how would they balance the need for investment between the long term and the short term?

ORLANDO DE PONTI (PRESIDENT, ISF): I think this is an excellent and very relevant question because, yes, I mentioned it before, whether we like it or not, plant breeding takes time and the problem is now. But I very much like your comment asking what about the current varieties. If you have a problem in a particular country where you would like to have better varieties, better seeds, be aware that hundreds of thousands of varieties are around. I think what you are also indicating is to test what is available. Variety testing is a very important and a very powerful means for the short term; variety testing by the farmers. You have to manage it but it is a low-cost activity. Very clear indications are needed of how to do it in a proper way so that you know for a particular country, and you can collect varieties from around the world from comparable climate zones and you find out what is the variety or varieties which are best suited. Then the next step is to have them multiplied and taken to the farmer. It is a very effective short-term activity and it has been overlooked for the reasons you give – yes, it's more sexy to do something new and then it takes 10 to 15 years, so start with what is available. You can only sell the seed that you have in your warehouse; you cannot sell the seed that you still have to breed!

THOMAS OSBORN (FAO): It seems to me that one of the elements you are bringing up is the weakness in national seed systems, and when we say national seed systems, that includes research, the seed companies, the private sector, the farmers, the national seed services, the policy makers. One of the ways to start to look at how you can improve the linkages between all these stakeholders in the seed sector is through a national seed policy formulation or reformulation process that brings all those stakeholders together and moves that process ahead. Now, of course, that is not the end of the issue at that point in time, but in the follow-through they come up with a seed policy that they themselves have developed with help from FAO or others. This is a first step in addressing some of these issues. This is one of the issues that came up in our private sector discussions earlier this year.

WAYNE JONES (OECD): I think you raised the point that I ran over very quickly and that is, there is more and more focus now on trying to develop these input markets for seeds or fertilizers, even for credit. I think we are a long way from having effective systems in most developing countries, but there is a focus on that. There is much less focus on developing the output markets, the marketing systems, which also need to be in place. A number of people have mentioned the fact that even if they have access to these, farmers will not introduce them if they don't have the revenue or the means with which to buy them. Even if they have the credit to buy them, they may still not because there are no risk management tools available to them. They have no crop insurance, they have no social safety nets and the market is highly volatile. Something has to be done there. A perfect example of what not to do happened with the rising prices in 2007/2008 when, for the first time in many of these countries, prices went to a level where the smallholders could actually start to look at some positive income. So what did many governments do? They introduced export restrictions so they couldn't participate in the higher prices; they introduced import tariff reductions and they increased local competition, so again the economic rent that the local small producers could have received was lost to them. The OECD message which is very important is to keep international markets open in this case and let farmers benefit from those times when prices do go up.

JOHN KEDERA (KEPHIS): Just to add to what has just been said is the whole element of how agriculture has been approached in most of our countries. It has tended to be more social welfare. Farming, because it started raining, or because your neighbor planted and that kind of scenario. There is slowly a shift toward making agriculture a business even when new companies come in. If I were to give the case of Kenya: in 1978 it was very hard to talk about many companies in the country, but now they are slowly coming in. The other expectation was that a big company would come into Kenya and jump into the fray and have a larger market share. You have to go in and learn the art of how business is done in the country and that kind of scenario. It is not what should be encouraged, but it is the system to enhance and allow the farmer to produce. So the partnership that is being talked about between the private sector and all elements of credit and the rest is what needs to be looked at at policy level.

DOUG WATERHOUSE (AUSTRALIA): I would like to pick up on the two points. Certainly, the message has to be to policy-makers for some sort of integrated, comprehensive, cohesive system. However, and I think that John Kedera has pointed to this, and so has Wayne, I don't want the public sector to go to sleep. I think that they have a very important role, particularly in the input markets. Wayne talked about the lack of risk insurance and this is part of the role of private industry to start to share with the farmers that risk and to develop business models that work with farmers so that the industry receives its remuneration when the farmer also produces a successful crop, the so-called end-point royalty type of model. There are lots of different implementations of this; ways that private industry can, not just partner up with government, but also partner with the real partners here, and that's the farmers. I would strongly encourage the development analysis of these sorts of different business models in countries where they haven't been tried so far. It works effectively in some developed countries, such as Australia, but certainly it looks like it could also be worth investigating in the sort of situations that we are talking about here.

RAOUF GHARIANI (PRESIDENT, BADDAR AGRICOLE, TUNISIA): For the last few days we have talked of many interesting things for our work. It would like to speak as the professional I am from a country where today we have a number of investment opportunities in the seed sector and I would like to make some comments and also raise some questions on aspects of major concern for the future of breeding activities in a country such as Tunisia. Our market is a small one; we have a population of 10 million, with important markets in neighboring countries with a strategic location, however, unfortunately the rules implemented by the neighboring countries make trade in seed very difficult, if not impossible. Seed circulating between Tunisia and Libya, for instance, is treated as a product of contraband. The rules are hard to abide by and in order to carry out sustainable investment activities it is very difficult, even though there are quite some opportunities. On the other hand, we have over the last two days talked at length about efforts by international and national bodies responsible for the seed sector and many of the views and positions expressed here are not, in my opinion, relevant in the exercise of my profession. I see many rules and regulations, but there is a good deal of muddle at the end of the meeting, because I would like to respect the rules but when I see that the FAO has its own rules, that ISTA has its own rules, that you have to be a member or be accredited to ISTA, that I have to make a large investment to become an accredited laboratory to meet international standards, I think that now is the time, after a meeting like this, to look a little more closely towards countries such as mine, where we have the possibility of doing specific activities, because we have a certain ecotype, we have commercial opportunities, we have a history in the industry. It is unfortunate that we continue, with so much work done over the last few years, and I am grateful for all the efforts made by everyone, but I think at the same time, we should be looking towards certain countries, and I had the honor to be President of the Association africaine des commerces des semences – and I saw the difficulties that African seed companies had in exchange, first between themselves and then to set themselves up as seed companies following international practice. It would be easy to continue commerce from the North to the South, but we have the ecotypes, we have the material and we have possibilities. We have skilled manpower, and apparently it will be skilled manpower that will be lacking, that's what one of the sessions over the past few days stated. Why are we doing nothing to make the processes a little more practical in the field in our counties, so that investment can be something palpable and concrete? Farmers are requesting high quality seed. Where will we be in several years if we continue to talk without taking any decisions?

THOMAS OSBORN (FAO): I want to acknowledge the speaker from Tunisia. We had a meeting in Tunisia related to seed, but more related to wheat rust a few months ago. I think Tunisia and the North African countries do offer a lot of potential because of the markets they have, the level of development, the vegetable industry and the level of agricultural development. At the meeting that we had there were four of the North African countries represented: Tunisia, Libya, Morocco and Algeria. FAO has been involved, with our partner organizations in activities to harmonize seed rules and regulations between countries in Southern Africa a while ago, but more recently in the ECOWAS countries of West Africa, and COMESSA is now requesting a similar kind of harmonization activity to increase the trade of seed between countries. I think if there is interest among the Maghreb countries of North Africa, as part of their economic community, to undertake this type of activity then FAO would be happy to be part of that process. It is to the advantage of the countries to have that free movement of seed.

JOHN KEDERA (KEPHIS): In listening to the comments that have been made so far on the question, one of the things I see as a challenge is how we can move this discussion we are having here to the national level. That is where action is required. So it might be appropriate to look at systems that will allow us, at the international level, to move these issues to the national level so that we can access that seed implementation.

BERNARD LE BUANEC: That was almost exactly what I was going to say. The objective of the Conference here, and we will discuss this at the conclusion, was to identify the main issues or the main decisions that have to be made for improving and facilitating the development of new varieties and the delivery of good quality seed to farmers. But we can only discuss the general environment and pinpoint the main issues here. The specific topics will have to be discussed at regional and national levels as, obviously, the objective of this Conference is not to take a decision on a very specific issue. The objective is to raise awareness and then to give some arguments (with the bullet points we have agreed upon) to governments to get things moving.

ADELAIDA HARRIES (IOWA STATE UNIVERSITY): It is more or less related to the last intervention because the panel also said that it is necessary in developing countries to solve the problem of the movement of seed. First establishing a national seed policy with all the stakeholders together, but it is very nice for countries to have a White Paper with a national policy. The problem is the implementation. For me, the role of the private sector is very important, working together with the government. The capacity of the public sector, the seed associations at national or regional levels, for the advocacy or the lobby depending on the country to work on that and to have clear rules implemented to facilitate seed production and to facilitate farmers' access to improved seed. My question to the panel is my concern that it is not only the seed policy document, it is the implementation of the system.

THOMAS OSBORN (FAO): The seed policy is a process and the development of the policy, as you said, is the first step. I totally agree that it is not about having a nice report to put on the shelf but to provide the framework for better cooperation and collaboration of the activities in the seed industry. Seed "policy" is probably not the word I would like to use, it is more that everybody has a common shared vision of the seed industry in the country, and must be able to pursue that in an appropriate way. Of course, this is something that requires effort and can require funding, but certainly the commitment of the different partners and the role of the private sector and of the farmers is essential.

FRANCIS OBONGO NYACHAE (SEED TRADE ASSOCIATION OF KENYA): I wanted to follow-up on the areas where I think the panel can intervene. As I mentioned earlier, harmonization of seed policies and the regulations in Africa has been going on for quite some time. Governments in Africa, as you are aware, are heavily involved in seed regulation and so forth. In some countries, it is the public sector which is actually responsible for seed supply. Therefore, following this harmonization which has taken place, several countries have responded. In some, they even have legislation now that supports the development of seeds. Somebody mentioned SADC and that the meeting running now is expected to endorse some of the agreements. In COMESSA the same thing is happening. COMESSA has taken up some of the programs in Eastern Africa and they have intervened by saying that, yes, they will support this harmonization. What I am asking is where interventions can come, especially from international organizations such as FAO, OECD, ISTA and UPOV and to ask you members to conclude or to pass these regulations, so that they can remove the bottlenecks that have been hampering trade. I know that these regulations remove those bottlenecks, but then without the law being in place, if it's a Bill or a policy for 10 years, that does not help the private sector. So my first prayer to you is: can you do something about your own members? Tell your members, those who have not yet concluded the legislative or regulatory frameworks, or even institutional frameworks, to do that. The second issue is that of the private sector. I can again quote from Sub-Saharan Africa, with which I am more conversant, that efforts are being made for the private sector to participate fully in the improvement of seeds. The truth is that without the private sector, we can talk here for years and years and very little will be done. My request, especially, to those organizations such as FAO, who have done a lot in countries like Africa to develop the seed systems, is that I really wish that they would work more closely with the national or the regional seed associations to be able to propel the program forward. I know that FAO works with governments and governments, if they are the ones in charge of seed, will not be involved in the private sector. Can we advance this? If you can work with the private sector through governments, then maybe we shall be able to move rather than talk.

XAVIER BEULIN (CHAIR OF IFAP GROUP ON GRAINS AND OILSEED): I would like to use this opportunity after these three questions, to tell you about what's happening in France. For a number of years, farmers and producers have not only understood the purpose of action in the field of seeds, but they have invested in seeds through cooperatives and private associations and this has made it possible to consolidate the sector to make sure that there is a close responsibility between producers, the farmer, and the seed producer and other links and this has given rise to associations which bring people together around a question of seeds and these people now are interlocutors with the authorities and can discuss standards, harmonization and their varieties and also lobby and make representations between the professions and branches and arbitrate on different opinions. We haven't succeeded everywhere; we are part of Western Europe and we have arguments on biotechnology which are very difficult, but with regard to fundamental tasks of seed production, it shows that there is interaction between the interests of the producers and all those working in the area. When I say interest, people have been saying for a couple of days and this morning in particular, everyone recognized the importance of not just investing. We need human resources too in this very vital area of seeds. It is said that productivity gains will come 50 per cent from genetic improvements and it's clear that if we are able in seed production and among users - the farmers - if we can bring our interests together, then it would be possible to deal with investments better, but also to make sure there is a fair relationship with other authorities in other countries, because that is a very important question too.

ORLANDO DE PONTI (PRESDIENT ISF): I would like to strongly support the remarks made by Raouf and Obongo, I say this as a representative of the private seed sector because we have mentioned a few times that it is extremely important to have an enabling business environment. I think it is very wise that it has been mentioned once more and I would like those people who are in charge, and we all know the important role of FAO, to support those countries and regions so that from the very beginning they bring representatives from the private sector on board in order to make sure, not only that the legislative and regulatory documents are in place, but also that implementation will be done in an effective and efficient manner and I am sure that, especially for the last point, the representatives from the national seed associations, from the companies, can really contribute to support the development of an efficient system.

THOMAS OSBORN (FAO): I think many of the issues with harmonization are the same issues we have with seed policy implementation at the national level. It's not just a matter of harmonization as the speaker has pointed out, but implementation. What we found is that many of the countries say that now we have harmonized standards, we need help in order to come up to the technical level to be able to implement those standards. I assume that is one of the topics that Joe was talking about in terms of work that they were following up in SADC. Certainly in terms of ECOWAS and the recent signature by the ministers of the harmonized standard for the ECOWAS region, we now have the same issue: we need to help them with implementation and to find donors that are interested. Donors haven't been so interested in capacity building, in implementing standards, but we will continue to pursue that. I think it is a good point; we do need to bring this to the attention of the ministers of agriculture and we will do that in the forum here at FAO.

ROLF JÖRDENS (UPOV): A brief remark from the standpoint of UPOV. There was a wish to encourage members of organizations to implement the systems. With UPOV it is the other way around. A country can only become a member of UPOV if it has the UPOV system in place, if the UPOV system or national legislation based on the UPOV Convention is operational in that country. That is perhaps important to note here. However, with regard to new members, we, as an intergovernmental organization, cannot take the initiative. The initiative must come from the governments of potential new members and in order for that to happen, it is extremely important that the breeders in that country, together with other interested parties, engage in a debate with the government and make clear that an enabling environment is essential if new varieties are expected to be made available to the farmers and growers. A joint effort is required; the profession must really explain the matter and, of course, events such as this one, which was right from the beginning aimed at encouraging governments to reflect on these matters, must come together. A joint effort is required. The initiative is important from those directly concerned; they must be very clear and very strong.

WAYNE JONES (OECD): At the risk of repetition, when the OECD hears people, particularly from industry, talking about the need to maintain open markets and facilitate trade, it is something that we very much support. That's the whole reason behind the OECD Seed Scheme – to help facilitate trade. Certainly, when countries apply for membership in that Scheme, the members have to go to the country and look at the processes in place and try to provide some advice on developing capacity so they can participate in the seed trade. It seems such a no-brainer that the benefits both from the export and the import of hybrid seeds are hard to justify not moving on quickly. That is why, in the strategy for the Seed Schemes, one of the key proposals is to become more engaged in the policy debate, because these are the issues that are quite important. You are absolutely right, it's the implementation that's important and that is why there is a need to spend more of your time on the policy engagement rather than just the technical side. One comment about aid: a lot of the funds that go into developing underdeveloped countries come from international aid and in the past that aid has gone to "sexy" projects. It's nice to produce fertilizer, build roads, but quite often there was a crying need for the institutions and the infrastructure. Now, at least under the Paris Declaration, member countries themselves are supposed to be calling the shots of what they need and listing their own priorities. I think there is a chance there to make sure that the aid institutions, the international organizations, play by the rules of the Paris Declaration and begin more and more to listen to the priority of needs in countries like Tunisia.

MICHAEL MUSCHICK (ISTA): I want to say something on the comments of Adelaida Harries and also of Mr. Obongo. I am fully behind Ms. Harries saying that implementation is a topic here and with implementation there are also the training aspects. I can only repeat what I said this morning: training is an important issue and we all need support from national governments and from the private sector in these regions as well as from capacity building organizations, to be in the position to provide the necessary training. That is a key issue and we see that at the ISTA level very clearly. We try to help where we can, but we also need some support.

MARCEL KANUNGWE (AFRICAN SEED TRADE ASSOCIATION (AFSTA)): I just wish to extend the great appreciation that made it possible for me to attend this Conference. I am President of the African Seed Trade Association. We have already discussed at great length the issues of private/public partnership. I want to re-emphasize that representing the seed industry in Africa, I have noticed some areas, some of which we have discussed here. We have our governments which we need to push on a lot of issues, then we have the emerging private sector, particularly in Eastern and Southern Africa, and then we have got quite a number of international and local agencies. My appeal is that finances are limited and we have talked about cooperation. A lot of emphasis has been put on the informal sector. I just want to assure the delegates here and particularly the key persons who are involved in the policy issues, that as far as the seed industry is concerned, we regard the informal sector as our reservoir for future business. So we are very interested to see that there is progress in the informal sector because it forms the backbone of our future business. In our request to engage with both the public and the international organizations, we just want to see how we can rationalize the limited resources that are available and I hope that by meeting the people concerned at this Conference will enable us later on to make the necessary approaches so that we make rational use of the limited resources.

ZEWDIE BISHAW (ICARDA): I think some questions are being asked already regarding the policy element and my question is where the government is willing; we have policies, regulations, which are in place. As I have said, implementation to me is much more than that. Implementation comes from the commitment of the government. It is not a question; it is more of a comment: how we, as a group, not only those who are sitting on the podium, the national programs themselves will come together and be able to influence the policy-makers. Because one commitment, for example, is that countries have to put 10 per cent of their GDP into agriculture. What would be a strategy to really make sure that even that investment could be made?

BERNARD LE BUANEC: This is, as we have said, a national problem and the objective would be that you take the conclusions of this Conference and go to your government or to the various governments to say that these were the findings of this international Conference, now can we sit around a table to see how to implement them?

JOSEPH CORTES (SEED SCIENCE): Mine is more of a request. As one of the guilty parties, together with FAO and other organizations, attempting to harmonize policies and regulations that will favor private sector expansion, I have to agree with many of the previous speakers who have mentioned that implementation is perhaps one of the areas where we see less and less effort and funding being placed. There seems to be this conception that after signature by the ministers of agriculture everything is perfect and we don't have to worry about anything else. On the contrary, that's just the beginning. The FAO representative mentioned it, Obongo mentioned it, there are many who have mentioned that this is an effort that is going to take at least another three to five years until everybody is up to the same technical level. Now, as people who are involved in trying to implement this, it is extremely difficult to find funding to bring 15 SADC countries up to the same level of funding for bringing six countries of Central America up to the same level, or 17 countries from West Africa up to the same level; those funds are simply not there. So what is my request? I think that all of us have access to donors in one way or another; we have access to donors in every one of the countries that we are talking about. If all of us, collectively, every time that a donor says he wants to do something in seed, the very first thing you say is that we need to implement this and part of the funding goes to making sure that that piece that is missing is, in fact, conducted. It doesn't matter that it is conducted by donor A, B, C, D; that's secondary. So that is my request to all of us when we talk to donors; let's tell them about the importance of implementing the regional harmonization frameworks. Otherwise it will take 20 years.

JOHN KEDERA (KEPHIS): I agree with what you are saying but at our own level we also have to put some things in place. Recently, I read an article that said "Bill Gates has 24 hours", it also means we have 24 hours. What do we ourselves do at the national level? It is not going to be something coming from outside, it has to be accepted at the national level. This is what we must do. So that whatever the donors come up with is what you are going to implement and that is where the challenge starts.

BERT VISSER (CENTRE FOR GENETIC RESOURCES, WAGENINGEN UNIVERSITY AND RESEARCH CENTRE (NETHERLANDS): It might sound like an open door, but I always seem to sense that it is necessary to stress it, and it is that whether you talk to national governments about implementation, already you talk with donors to see what they can contribute; whether national donors or the Gates Foundation. It is important to link with the perspective of the donors and national governments, not necessarily your own. It is also important in my own experience to look at any activities that you propose from a perspective of what they contribute to food security at the global level; what they might contribute to sustainable development. What they can contribute to rural development. Don't start with a quest for harmonization but place it in a larger framework. That is very important in any discussion to get an interconnection between governments and donors.

ANDY LAVIGNE (AMERICAN SEED TRADE ASSOCIATION (ASTA)): I look at what we have heard over the last two days as great opportunities for going forward with some challenges that the seed industry has to address, given the evolution of the industry that the innovations, new technologies that are there to address a lot of the issues. The plant breeders of this industry have, as we have heard, risen to the occasion to increase yields and have the opportunity to continue to increase yields down the road. The bigger issues of the developed countries that we have, or challenges that we have in the plant breeder community, will I believe be solved. But if we don't come out of these three days with some ideas other than five areas with 10 topics that we all agree on and no goal of some kind of things to come back with in 10 years, I bet that the list in 10 years at the Third Seed Congress will look the same. We'll still have dying plant breeders, we'll still lack laboratories; we'll still have challenges with our phytosanitary rules; we'll still have challenges for training. My challenge to us, and especially to the organizers, was how do we think outside of our box. It seems like what we do is we go and we sit down with a country and say: "You need to become a member of, in this case ISTA, and you need to set up your labs and you need to train. You need to adopt IPPC standards, go ahead so that we can move seed in and out of your country." The capacity just to start the process in each of those areas for governments is not there, let alone the capacity to have lab staff, to have plant breeding programs to set up a germplasm system. Can we pick 10 countries so that in 10 years when we come back we have examples for the rest of the world of where we can develop bases and other programs? That, to me, is an option. If we talk about the problems we have today, we won't make the leap to find the solutions for tomorrow. Our organizations, whether they be public or private, have that opportunity to make the changes. Many of our countries, our companies, are doing business in these countries and I would challenge the panel and the governmental organizations as well as the ISF, the regional seed associations and the national seed associations, to come together to figure out ways where we can find different solutions in these countries and establish examples for growing the seed industry and improving the lot of the worlds' farmers in the future.

WAYNE JONES (OECD): I am not sure it is a reaction to the proposal, but I think I am quite sympathetic to it. Quite often at the international level when we see the statements coming out of meetings on food security, on agricultural development, they are very bland. They are statements like: we need to use 10 per cent of the national budget on agriculture; we need to increase the proportion of aid to agriculture back to where it was at 17 per cent. These are just numbers and they don't help much in the policy debate. As I said in my first intervention, really what groups like this need to do is to provide the details, to tell the politicians what to do with that money: What to do and how to do it. That implementation advice is what is really missing and that is where the linkage between the international policy debate and organizations like this needs to come. There is a good reason why national governments and international aid agencies withdrew from agriculture: a lot of the money put into agriculture was deemed not to be very successful: low returns or no returns at all. Similarly, there were other opportunities such as education or health that they could put their money in and which they thought gave higher returns. That's a logical, rational decision on the part of policy-makers and normally, if you understand what's at stake, you'll find their decisions are relevant. One of the messages we need to get across and IFAD is quite good at that, is showing that times have changed and both the need for and the return to investment in agriculture are looking much more positive than in the past. I think this is what we need to work on. In the OECD we are trying to learn more about agricultural development. We are trying to develop a much stronger argument for investing in agriculture as a major way for economic growth, particularly in developing countries. There is an argument for it but it's hard to prove. We are trying to develop an analysis that can do that. We understand that the kind of development strategy is different for virtually every country on that path to development. There is no one-size-fits-all, certainly not the policy experience from OECD countries for some of the least developed countries. We are trying to understand the priority of things that need to take place in that regime. I would still like to come back to my first point, which is all your good intentions will fall on stony ground unless a lot of the other barriers and intransigencies are removed at the same time. There are all kinds of policy distortions out there that restrict trade: the tax on agriculture in some countries; the failure of input markets; the failure to have significant returns or any kind of risk management for small producers in developing countries that would encourage them or allow them to take the chance to use the kind of technology you are talking about. All of these things have to be in place for strategies on increased research and research transmission extension to work.

ORLANDO DE PONTI (PRESIDENT, ISF): I thank that Andy raised a very good point in trying to convince the organizers of this Conference to become more concrete about the action to be taken and to do that in collaboration with those people who are familiar with the issues, like national associations, regional associations, etc. But I would like to mention to all of you that about a year ago, before we were all occupied by the financial and economic crises, we were talking about the food crisis and in this house, there was a high-level meeting organized by FAO, and then later on in August at the United Nations headquarters at their invitation, and they already decided a year ago on a strong plan of action for improving seed systems around the world, especially for those countries where there is a still a great need. The ISF was represented through its Secretary–General and we stated very clearly that industry, the private sector, is very willing to participate and to offer support in whatever way that is related to their competence. Industry is not going to take the lead; this is an issue that should be taken care of by governments and we pinpointed very clearly that, as far as we are concerned, FAO should take the lead and any time they call on us, the ISF would be willing to reply and to call on their members to do whatever they can. Maybe it is a good moment to ask FAO where they are since those two important meetings a year ago.

THOMAS OSBORN (FAO): I agree that we need to think outside of the box. I think calling this meeting and having it as a collaborative meeting among many of the institutions and the private sector involved in the seed industry is an important step. We need to coordinate and work together more effectively. In terms of the promises that were given to FAO by the donors, there were big numbers, but a lot of the numbers seem to be a bit empty, although when we received money, some of the activities went into seed systems. The work we are doing in Afghanistan, a project going on in Burkina Faso, Mozambique: these are three of the bigger projects we are implementing with European Union funding. But there is more work to be done. We are working with the African Union on the African Seed and Biotechnology Program as a framework with the member countries, with our partners. This has been slow in setting up, but I think we're moving that forward as well. I think we are trying to do our part and we are trying to secure funding, but just like all other efforts, you need funding and support in order to make these things happen in the field. I think there is a lot of potential and we will continue to try to work together to see how we can push things forward. When you intervene in the seed system or in agriculture, it is complex. If you just have the IPR issue solved, or you just have the seed testing solved, that's not enough. There needs to be intervention and success in a number of areas in order to make things work. In the context of this meeting, what we are trying to do is to move forward in a more coordinated way.

BERNARD LE BUANEC: Obviously the suggestion made by Andy Lavigne is interesting and I would encourage the five organizations to call a meeting soon to see what they can do. The difficulty will of course be to agree on the pilot countries. I can tell you that tomorrow morning there will be a meeting in this building to see if it is possible to set up a specific project in some pilot countries. The message has been heard and I will really encourage the five organizations to go further on that – it is a good suggestion – and we already had that in mind.

HOSEA SITIENEI (KENYA SEED COMPANY LTD, KENYA): I think we have all agreed that we have a crisis, the crisis of hunger globally, and particularly in the Third World. This is despite the fact that we have better varieties today, better seed than in the past. What I have observed is that one of the problems is that seed, even where systems exist and work, is not affordable. Seed is quite expensive for the rural farmer. Some governments have gone into the question of subsidizing the seed and other inputs. I do not know whether FAO and other donors are encouraging this kind of intervention so that the farmers can get seed, because I don't believe you are going to talk about breeding new varieties to solve today's problems. I think we have the seed that we have today and that seed is able to solve some of the problems, but it is not affordable to the majority of farmers. Do you encourage subsidies the way some governments are trying to?

THOMAS OSBORN (FAO): Do we encourage subsidies? I would say no. But on the other hand, for emergency situations or vulnerable households who have lost their means of livelihood, drought, floods, civil conflict, we provide seeds and sometimes fertilizer and other inputs to help them recover from an emergency crisis. So I don't necessarily consider that as a subsidy, but those are the conditions under which we would provide seed on a free basis.

BERNARD LE BUANEC: I know that the question of subsidies is a question that has been discussed quite extensively for many years and that it has been considered that giving subsidies to buy seed depends on how it is done. It can be detrimental to the emerging private sector if it is not done properly. It can be extremely useful if it is done properly like, for instance, a seed voucher. But if subsidies for seed mean just giving seed from somewhere to the farmers, it is a catastrophe for the emerging private sector, so we have to be extremely careful.

GARLICH VON ESSEN (EUROPEAN SEED ASSOCIATION (ESA)): I would like to come back to the title of this panel discussion: "providing an enabling environment". I think that is exactly why you are sitting up there. Industry and the member states have chosen their enabling environment: your organizations for the representation of industry, for quality assurance, for facilitating international trade, for assuring seed health, so I think what has come out of the three days is very clearly that we know how to do it. There is a clear choice among countries as well as industry about what kind of environment we need and that, indeed, ensures progress. Now, obviously there are obstacles. There may be a lot of things that can still be improved. I think the stronger involvement of the private sector is one of those and that definitely depends on the development stage of the country. I think where we also need to look in detail is where we see contrary movements, basically a disenabling environment if you like. That doesn't usually come from your organizations; it comes from other organizations and perhaps one of the demands or requests that could come out of this Conference is that those organizations that provide the enabling environment also have to speak up more loudly and more clearly to those that make things difficult for the seed industry and for the seed sector in general. That is when you place too many burdens on one single input factor. Just with seed, we are not going to change the world, it is only a part of that. So if you try to have environmental goals, public health, development goals, all placed on this one tiny sector (Bernard has pointed out how tiny it is) I think we are trying to do a bit too much. But if we could ensure that these organizations, with their credibility with governments argue their case and make sure that we don't get disabling legislation as in many parts of the world, and we can talk about Europe there if need be, then I think we would already make progress. Going out and lobbying for this is not only the job of industry, it is the job of these organizations and that is why they have been set up, to encourage you to speak out in favor of this important sector, not only to us because we know, but to your colleagues who disagree.

BERNARD LE BUANEC: What you are raising is a problem of coordination among governments within one country and obviously, if each of those organizations here could have a role at their national level to try and get that harmonization at the government level, that would be very interesting, but it is difficult.

ROLF JÖRDENS (UPOV): The organizations are of course the members. It is not the secretariats which govern and shape the course of the organizations, it is the members. But what we as offices, secretariats, of those organizations can do and what we try to do is to inform our members, in the case of UPOV, about what is going on in other fora. Then it is the role and the responsibility of the individual members to try to coordinate action at a national level. That is all that, we at least, as a secretariat, can do within such an organization.

ISMAHANE ELOUAFI (CANADIAN FOOD INSPECTION AGENCY): My question to the panel is in relation to the public plant breeding sector, its importance and maybe its transformation in the new era, so I am wondering if we are witnessing right now the disappearance of public plant breeding programs in national and international institutions and I can say that in Canada, we have a decrease of funding in plant breeding and also a shift of priorities away from plant breeding. I think I can see the same thing in the CG Centers. So I would like the panel's view on this and how they foresee the future for public plant breeding.

ORLANDO DE PONTI (PRESIDENT, ISF): I can give a short reply on this. I would say this is evolution; this is a very natural process. If you go back 200 years, there was only public plant breeding. Step-by-step, depending on the degree of development, private people, private industries have appeared and they started to develop commercial varieties. Of course, in the beginning this was sometimes in competition with public varieties, but then in many countries the government said: "We have an effective private sector, so let's do other things". So it moves up from commercial breeding in the public sector, to what we call "pre-breeding": the basic understanding of genetics, new traits, which is then passed on to the private sector in order to produce the very best varieties and this has happened in the Northern countries and it will happen in the Southern countries: it's simply a matter of when and how and where.

ROLF JÖRDENS (UPOV): Another remark from the standpoint of UPOV. The systems of IP protection, including the UPOV system, encourage breeding in those areas where there is a commercial market. The UPOV system cannot, of course, encourage breeding in sectors and for crops for which there is no existing or potential market. It is nevertheless very important to integrate this effect into a national breeding policy. The public sector can then concentrate on those crops which are not taken up by the private sector because there is no commercial market. There is the possibility to reshape priorities in public sector breeding and to do more with the same or perhaps with less money, because you have here shared responsibility and complementary action of the private and public sectors. That is perhaps one of the answers that can also be given in this respect.

BERNARD LE BUANEC: I think we have to think more in terms of complementarity than in terms of competition.

VICTORIA HENSON-APOLLONIO (CGIAR CAS-IP): I head up the Central Advisory Service on Intellectual Property. Because we are fortunate to have this meeting in Rome, I have our entire CAS-IP team, so we have six people attending this meeting. You might ask yourself why. I am curious to get a response from the panel in terms of what they see as the role of people who are in IP practice and technology transfer practice on the ground. We work very hard to occupy that layer where we try to work with what implementation there has been, and to see how far we can push it. We are having a team meeting over the two days; we have come from all over the world, to get together to see what we have learned from this meeting. I am curious to know what your recommendations would be in terms of the role of IP professionals and people who work in trying to draft agreements and documents that help public/private partnerships and to understand what we can do on the farmer's side with quality seed to make farmers aware of quality seed and what it means to them in terms of their scarce resources. What do you see as our role?

DOUG WATERHOUSE (AUSTRALIA): I certainly can't answer in the broad sense, but I can pick up on one of the issues that may interest you, because you have many roles; you are dealing with donating and receiving and a lot of different things. There are two issues: the first is to do with your opportunity to help educate people about the responsibilities, obligations and advantages that come with intellectual property. One of the things that we see is that there is not often a very good understanding of the obligations in relation to a particular piece of intellectual property. Take the UPOV system, for instance, here it is very clear what the exclusive rights relate to, what the scope of protection is and how it is extinguished. But, in general, many receivers of material don't understand that very well at all. I think we all have an obligation to try to explain what the obligations are that are attached to the material that you receive. The second issue, and I would like to pick up on our colleagues from Iowa, where they highlighted the fact that if institutions don't have a credible and coherent IP policy, then it is very hard for them even to start to deal with these sorts of questions. So there is also some responsibility to help receivers understand this policy, and sometimes they are reluctant even to engage the thought of having an IP policy, because they really don't understand what that might mean for them. There is an opportunity for your team of six, which probably outnumbers some of the secretariats here, to spread the word and to encourage people to develop their institutional IP policies so that they can start to deal with materials to which intellectual property attaches everyday and it is not a threat to them, but actually an opportunity to facilitate whatever they want to do with this material. On those two points, I think that you have got quite a large job. But let me turn this back to the panel who may have other ideas about how IP professionals such as you may engage in this area.

ORLANDO DE PONTI (PRESIDENT, ISF): I agree that it is a very important question and I would like to re-read one of the conclusions of the first session. "Intellectual property is crucial for sustainable contribution of plant breeding and seed supply". Intellectual property protection is crucial, but it is a profession. I still remember the days when every plant breeder had some clue about UPOV. There were no lawyers in the companies and they were well able to do the business and were filing their varieties for PVP protection. I also remember the days when working in the private sector, I had to draw up a contract with the public sector – half a page was enough and everybody was happy and there was no problem. I haven't seen those types of agreements for the last 10 years, now it's rather 20 to 200 pages! There is a lot of legal wording in it and I would say, also from the industry, whether we like it or not, the reality is that there is a lot of exchange of IP assets and that is a good idea. There is an exchange in order to help each other to do a better job in making better seeds. But exchange is no longer by a handshake; it is by an agreement. I am very pleased to notice, and I learned a couple of years ago, that the CGIAR has also understood that there is a need for this type of professional, especially because you can see on all websites that the CG Centers are more and more engaged in public/private collaboration. "Collaboration" is a nice word, but it is an agreement, and I really wish you a lot of good luck in your good work, because you are six and if you count all the lawyers in the private sector, I think you get thousands! So it is very fair and very wise that the CG takes this role very seriously.

FRANÇOIS BURGAUD (GNIS): I just wanted to add that the African Seed Association (AFSTA) and the Asia and Pacific Seed Association (APSA) some years ago took a position in favor of plant variety protection. I would invite all those of you who do not know these organizations to go to their websites, to see that the breeding companies of which they are composed are not multinationals, but African and Asian breeders and sometimes very small seed producers. Second, I would invite the national and regional organizations to be more proactive at the national level. I recall that maybe governments have all talked on the need for public/private partnerships to be able to respond to the food crisis of several years ago, but today the private sector is not represented at the Food Security Council at the international level; we had to struggle for it to be accepted and it should be in the next reform, and I invite seed organizations to request observer status, because otherwise they will not be invited. I would like to break the consensus; we are all in agreement that we need a link between the farmer and the seed companies, however, Xavier Buelin reminded you, perhaps in too light a manner, that there are two ways of making this link. As we heard yesterday, African seed producers don't think that the African farmer is condemned to use only the seed in his traditional community, that he has the right to access quality seeds and genetic progress. For that, we need to redistribute aid and I repeat what I said this morning, the great majority of aid given to the seed sector today does not reach the people producing or selling seed in developing countries. For example, Thomas Osborn (FAO) mentioned the project in Burkina Faso financed by the European Union: 19 million euros over 2.5 years. None of the seed producers in Burkina Faso have been contacted. They are not mentioned anywhere in the project, which I have here. Public research is mentioned, all of the NGOs which "compete"' in the world of food security are mentioned, but the private seed sector is not mentioned. As long as we continue making projects such as that, we will not help the development of the seed sector. This message must be clear, to the farmers of those countries and to donors.

BERNARD LE BUANEC: It is true that there is still a lot of progress to be made in the area of synergy between the public and private sectors. There will be an item in the conclusions.

ANKE VAN DEN HURK (PLANTUM NL): In the discussions we have had this afternoon we were talking on a lot of issues we dealt with during the last two days. We didn't talk a lot about access and benefit-sharing and access to genetic resources and sharing them. It is a pity that Mr. Bert Visser, the Director of the Centre for Genetic Resouces at Wageningen University and Research Centre has left, but I would still like to put this question to the panel. Mr. Visser indicated yesterday that access and benefit-sharing were accepted differently in developing and developed countries. He said that in the developed world, we are looking at access and that in the developing world they are looking at benefit-sharing. When we heard the discussions we recognized, in fact, that for the seed sector, especially in developing countries, it is in principle the opposite. They are probably much more dependent on access because they don't yet have collections. I would like to ask the panel how they think we can get this message across to those people who are negotiating the international treaty, who are negotiating on access and benefit-sharing, to demonstrate to developing countries that they also need access and that it is very important for their seed systems and indeed to show this to the developed world.

ORLANDO DE PONTI (PRESIDENT, ISF): I would agree that access is, I would think, one of the key notions in effective plant breeding. That is also the reason why the breeder's exemption under UPOV is so important. On the one hand you have protection of your variety, so nobody is allowed to copy it and to sell it and compete with you, because then you get price competition, etc., but everybody is free to use it as starting material for another variety. I think it is a very important notion and that is the reason it has been re-emphasized, especially for those countries that are still in an early phase of plant breeding. If I had to do a breeding job in Zambia or in Sierra Leone, the first thing I would do, as a breeder, is to collect everything I could get from the wild, from the local varieties, from varieties from the same climate zone, from universities; the most varieties possible. I'd then plant them in the field, see what they were and then make my selections and my crosses. This is the fastest way to get to a variety that clicks in a particular country. Right access is extremely valid also for developing countries. If you turned that benefit into having free access for further breeding, if you translated that into real money, you would end up with an extremely high figure. It is an important contribution in kind and represents an enormously large figure.

BERNARD LE BUANEC: I think, Anke, that your comment is also linked to what François Burgaud was saying before. In discussions at international level on those aspects, industry is never invited, only the NGOs. You will remember how difficult it was for me to be able to take the floor in the discussions on the international treaty: it was said: "You are from industry, you should go to the balcony and you are not allowed to speak". So the ISF left the meeting. We are talking of good synergy – it is not yet there, but maybe the meeting of today will help to get there.

XAVIER BEULIN (IFAP): Just a reaction to your question, Anke. I would like to thank you for your invitation. I basically agree with what has been said in many international bodies. Farmers such as me are not always invited. A number of farmers' organizations are invited, not necessarily the one I represent. What is of interest to me is if a farmer that I represent sends an order for seeds, then I would ask that you produce more and better and good quality. But I come from a country where society expects something else. They expect answers about climate change, about biodiversity, about the environment, so it is a combination; it is not always easy to bring the conditions together. I would say it is important that there be convergence of opinion for the end users and those who will be using genetic potential and I don't think in developing countries either that we can do without combining legitimate attempts in the productive part of the economy, together with expectations that are not economic, but where we need to find a balance.

ORLANDO DE PONTI (PRESIDENT, ISF): I would like to mention one more time that the target of the private sector is to develop and produce the best genetics in the best seeds. I would like to highlight one important point. After development, it is a long road before we have the very best in a bag of seeds. I would like to re-emphasize the importance of seed processing, seed enhancement, and - this word hasn't been mentioned – quality control. Because you buy seed from a company and before the seed goes to the farmer, the company has to be sure that it meets the standards set by ISTA and the company. I would like to close my remarks by coming back to your question about assurance and insurance. Well, it's not an insurance, but when you buy seed from a company under proper conditions and it says that what you buy should be up to standard, if it is not, and it can be proven that it is due to faulty seed, and I know it happens, we get a claim and we have to pay.

JOHN KEDERA (KEPHIS): Just to say that those of us in the public sector are committed to using the international best practices that are available in an effort to remove barriers to trade. If those in the private sector find issues, we would like to you to continually raise them so that we can work together in the best interests of the seed business.

CONCLUSIONS OF THE SECOND WORLD SEED CONFERENCE

BERNARD LE BUANEC*

The Second World Seed Conference (Conference) recalled that agriculture needs to provide sustainable food security and economic development in the context of current and future global challenges. This Conference has highlighted the critical role of new plant varieties and high quality seed in providing a dynamic and sustainable agriculture that can meet those challenges. It is concluded that governments need to develop and maintain an enabling environment to encourage plant breeding and the production and distribution of high quality seed. The Second World Seed Conference identified the following elements in providing such an enabling environment:

- Plant Breeding has significantly contributed and will continue to be a major contributor to increased food security whilst reducing input costs, greenhouse gas emissions and deforestation. With that, Plant Breeding significantly mitigates the effects of population growth, climate change and other social and physical challenges.
- The International Treaty on PGRFA is an innovative instrument that aims at providing food security through conservation, as well as facilitated access to PGRFA under its multilateral system (MLS) of access and benefit-sharing. The MLS represents a reservoir of genetic traits, and therefore constitutes a central element for the achievement of global food security.
- Intellectual property protection is crucial for a sustainable contribution of plant breeding and seed supply. An effective system of plant variety protection is a key enabler for investment in breeding and the development of new varieties of plants. A country's membership of UPOV is an important global signal for breeders to have the confidence to introduce their new varieties in that country.
- Seed quality determination based on scientific principles before supplying the seed to farmers is an important measure for achieving a successful agricultural production. The establishment or maintenance of an appropriate infrastructure on the scientific as well as technical level in developed and developing countries is highly recommended.

The development of reliable and internationally acceptable certificates, through close collaboration between all stakeholders along the supply chain for varietal certification, phytosanitary measures and laboratory testing contributes substantially to the strong growth in international trade and development of seed markets.

Overall Conclusions

- Participation in internationally harmonized systems (ITPGRFA, OECD, UPOV and ISTA) is an important means for countries to increase the availability of germplasm, new plant varieties and high quality seed for the benefit of their farmers, without which their ability to respond to the challenges ahead will be substantially impaired.
- A predictable, reliable, user friendly and affordable regulatory environment is crucial to ensure that farmers, have access to high quality seed at a fair price. Cooperation between international governmental and non-governmental organizations, on the basis of mutual supportiveness, is essential in order to provide effective assistance to governments in the development of an enabling environment.
- The conference acknowledges the important role of the public and the private sector to meet the challenges ahead. It also recognizes the benefits in developing complementarity and synergy between the public and private sectors.

Urgent government measures and increased public and private investment in the seed sector are required for the long term, if agriculture is to meet the challenge of food security in the context of population growth and climate change.

* Chairman of the Organizing Committee

BIOGRAPHIES

USHA BARWALE ZEHR

Ms Barwale Zehr graduated with a BSc. in 1981 from Wilson College at the University of Bombay, India. After that she was awarded an MS and, in 1985, a PhD in Agronomy at the University of Illinois, US. Since 1991 she has been the Director of the Barwale Foundation and has worked as a geneticist in sorghum and millet at Purdue University, Indiana, US. From 1997 until 2006 she was a trustee of the M. S. Swaminathan Research Foundation in Chennai, India. She has occupied and is still occupying many positions, most notably as a board member of the Donald Danforth Plant Science Center and of IRRI and CIMMYT. Since 2000 she has been the full-time Director of Maharashtra Hybrid Seeds Co. Ltd., Jalna, India. With advances in plant biotechnology in recent years, her research interests have been in applying these tools to improve agricultural productivity. With the use of genetically enhanced crops and genomics, many opportunities have been presented for improving productivity in a sustainable manner. Use of molecular tools to enhance breeding activity, use of genomics to gain a better understanding of crops, deploying new tools to enhance the nutritional value of food grain are just a few of the possibilities. Her objective is to look at possible technologies and work to bring them to the farmers.

XAVIER BEULIN

Xavier Beulin was born on December 19, 1958 at Donnery, Loiret, France where he has farmed since 1976, cultivating 170 hectares of cereals and oilseed and protein plants. Since 2001 he has been the local President of the Conseil économique et social régional du Centre (CESR); since 1995 Economic and Social Council President of the Chambre départementale d'agriculture du Loiret; since 1990 Vice-President of the Fédération départementale des syndicats d'exploitants agricoles du Loiret (FDSEA); since 2005 first Vice-President of the Chambre régionale d'agriculture du Loiret; since 2005 national first Vice-President of FNSEA (the French national farmer's union); since 2007 President of the High Council of Cooperatives (HCCA); since 1998 President of FOP (the Federation of French Producers of oilseed and protein-rich crops). FOP represents 150.000 French producers of oilseed and protein plants.

Since 2000 he has been President of Sofiprotéol which is a financial corporation in the protein crop and oilseed sector. Since 1983, Sofiprotéol has upheld the development of oilseed products and protein-rich crops in France by providing appropriate financial and industrial resources. Since 2000 he has been President of Cetiom (the Technical Center for Oilseed Crops). Cetiom is a technical research and development organization serving French oilseed producers. It deals with the following main crops: rapeseed, sunflower, soybean and linseed. Since 2000 he has been President of the port of La Rochelle and since 2002 he has been President of the European Oilseed Alliance (EOA) which represents European oilseed and protein producers by defending their interests.

Xavier Beulin is chairman of the IFAP (International Federation of Agricultural Producers) Group on grains and oilseeds.

SHAKEEL BHATTI

Shakeel Bhatti was appointed Secretary of the Governing Body of the International Treaty on Plant Genetic Resources for Food and Agriculture (IT PGRFA) by the Director-General of FAO on January 29, 2007. Before joining FAO, Dr. Bhatti headed the Genetic Resources, Biotechnology and Associated Traditional Knowledge Section of WIPO. He was instrumental in the creation of the Intergovernmental Committee on Intellectual Property and Genetic Resources, Traditional Knowledge and Folklore (IGC) and served on the Secretariat of this Committee. Before establishing the IGC, he worked in the Development Cooperation (and Copyright Law) Division. Before joining WIPO, Dr Bhatti worked on his doctorate at Duke University, US on the scope of patentable subject matter under Article 27 of the TRIPS Agreement in relation to genetic resources and biotechnological inventions. He is currently completing a second PhD in bioethics, biotechnology patenting and the right to food.

MARCEL BRUINS

Marcel Bruins completed his studies in plant breeding and plant pathology at the University of Wageningen in the Netherlands in 1989. Based on the research he did on Fusarium resistance in wheat at Plant Research International, he was awarded a PhD in 1998. For many years he was responsible for the patent portfolio of a large public research institute and then worked in Rotterdam at the Innovation Center for Inventions where he was active in the commercial aspects of agricultural and biotechnology inventions. In 1998 he joined the breeding company Seminis Vegetable Seeds where he was Manager Plant Variety Protection WW but also worked on other aspects of intellectual property, such as patents and trademarks. During this period he served on several international committees in organizations like the European Seed Association, the Dutch Seed Association and the International Seed Federation (ISF). He has also chaired several of these committees. Marcel Bruins joined the ISF in 2007 as Secretary General.

MARCEL KANUNGWE

Marcel Kanungwe holds a diploma and a BSc. in agriculture from the University of Connecticut, US and the Haile Sellasie University in Ethiopia. He subsequently worked for 11 years in the management of livestock and cropping enterprises. Since then he has worked for 28 years in the management of different seed enterprises. After having served as General Manager of Pannar Seed for 11 years, he became Director in 2006. He was the President of the Zambia Seed Trade Association from 1999 to 2007 and is currently the President of the Africa Seed Trade Association (AFSTA), his two-year term ending in March 2010.

PETER BUTTON

Peter Button has been the Technical Director of UPOV since September 2000. Mr. Button holds a BSc. Honors degree in biological sciences. From 1981 to 1987 he worked for Twyford Seeds Ltd., a UK plant breeding company, in the development of new cereal varieties. Between 1987 and 1994 he was the General Manager of Twygen Ltd., a company which developed micro-propagation systems for the commercial production of seed potatoes and soft fruit stocks and continued as General Manager, following the change of ownership of GenTech Propagation Ltd. in 1994. In 1996, Peter Button joined the British Society of Plant Breeders as Technical Liaison Manager, where his responsibilities included the operation of officially licensed variety trials. In 1998, he became Technical Liaison Officer for the UK Ministry of Agriculture, Fisheries and Food (Plant Variety and Seeds Division), where he was responsible for the operation of the tests and trials associated with the UK Plant Breeders' Rights and National List schemes and Seed Certification in England and Wales and was the UK representative on the UPOV Technical Committee.

JOSEPH CORTES

Joseph Cortes was awarded a PhD in seed technology in 1987 from Mississippi State University, US. He completed his MSc. studies in 1979 in post-harvest technology at the University of Campinas, Brazil. In 1973, he studied agricultural engineering at the National University of Colombia. Since 1991 he has been Global Seed Program Leader at the Seed Science Center at Iowa State University and has held various positions such as Head of MIAC-Peru/Seed System Development at Iowa State University from 1988 to 1992; Assistant Professor/Research Associate, Seed Technology, Mississippi State University from 1984 to 1988; Training and Research Associate, Seed Unit, CIAT (International Center for Tropical Agriculture) from 1974 to 1975 and from 1979 to 1984 and, between 1975 and 1979, he headed the Food Department at Universidad Del Valle.

He has been involved in issues of harmonization of seed policies, regulations and development worldwide and has received many honors and awards including the following: an award from ASTA for Vision and Work in Seed Regulatory Systems Reform Resulting in an Improved Global Trade Environment in June 1999; an award from the Central American Organization for Regional Plant and Animal Health for Technical Assistance in the Harmonization of Seed Policies and Regulations in January 2000; an award from USAID/Peru for development of the national seed system in 1992; an award for excellence in seed science and technology from the Crop Science Society of America in 1991. He served as Executive Secretary of the Central American Regional Seed Committee in 1983 and as President of the Colombian Society of Agricultural Engineers in 1981.

ORLANDO DE PONTI

Orlando de Ponti is a graduate in plant breeding from the Wageningen Agricultural University, where he also received his PhD. After 20 years working as a scientist and research director in plant breeding and plant protection at the Wageningen Research Council, he joined the private sector. From 1991 until 2008 he was the Research Director of Nunhems BV, the vegetable breeding company of Bayer CropScience and from 2008 to 2010 he has held the Presidency of the ISF.

KATALIN ERTSEY

Ms. Katalin Ertsey is the ISTA President/Director at the Hungarian Central Agriculture Office with responsibility for variety registration including DUS and VCU tests, certification and marketing control of seed and propagating material and Honorary Professor at the Corvinus University Budapest She graduated from the University of Horticultural Science Budapest and her thesis was on the subject of the Evaluation of Alternative Methods of Vegetable Seeds. After graduation she joined the National Seed Inspectorate (one of the predecessors of the Central Agriculture Office) and for the next 15 years she passed through the ranks to become leader of the Central Germination Laboratory, head of the Hungarian Seed Certification Scheme, and in addition, five years ago, she took over responsibility for national listing and variety registration. In 1995 she completed her PhD with a degree thesis on the Effect of Seed Vigor for the Value of Vegetables. During the transmission period leading to the adhesion of Hungary to the EU she worked on legal harmonization, extending her mandate in Brussels. She has wide-ranging experience in variety testing, seed production, processing, seed physiology, testing and seed legislation and comprehensive knowledge on bilateral and multilateral cooperation. In 2006, she became an EOQ (European Organization for Quality) Quality Manager and Auditor. She has been a member of the ISTA Executive Committee since the 23rd ISTA Congress in Buenos Aires in 1992. During the triennium 2007 to 2010 she is serving as President of ISTA and has been nominated as leading agricultural expert during the Hungarian presidency of the EU in 2011.

ELCIO GUIMARÃES

Elcio Perpétuo Guimarães received his BSc. degree in agronomy from the Escola Superior de Agricultura Luiz de Queiroz in Brazil and was awarded an MSc. on genetics and plant breeding from the same university. In 1976 he began working as a rice breeder at EMBRAPA. He obtained a PhD degree in 1985 from Iowa State University, also on genetics and plant breeding. From 1989 to 1996 he worked as a rice breeder at the International Center for Tropical Agriculture (CIAT) in Colombia. In 1996 he returned to EMBRAPA where he remained until the end of 2001 when he became a senior officer at FAO. In his career he has been responsible for releasing several rice varieties in Latin America and has published and edited several books and technical articles.

JOHN HAMPTON

John Hampton is Professor of Seed Technology at Lincoln University in New Zealand and Director of the Lincoln University Seed Research Centre. He completed an MAgrSc. degree in Plant Pathology at Lincoln and then a PhD in Agronomy at the University of Nottingham, UK. His research interests include conventional and organic seed production and seed quality. In 2006 he was made a Fellow of the New Zealand Institute of Agricultural and Horticultural Science. He has been involved with ISTA for nearly 30 years, and is the current first Vice-President.

COSIMA HUFLER

Ms. Cosima Hufler chairs the Bureau of the 4th Session of the Governing Body of the International Treaty on Plant Genetic Resources for Food and Agriculture (IT PGRFA). She is senior advisor at the Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management, in charge of international environmental affairs. Her particular focus is on matters related to access to genetic resources and the fair and equitable benefit-sharing arising out of their use in the context of the IT PGRFA, as well as of the Convention on Biological Diversity (CBD). In addition, she is in charge of international sustainable development issues related to the UN Commission on Sustainable Development (CSD) and the United Nations Environment Programme (UNEP). After completion of her university studies at Innsbruck and Vienna, Ms. Hufler worked as a translator. She is a graduate of the Diplomatic Academy of Vienna (with particular focus on international environmental law and institutions).

WAYNE JONES

Wayne Jones spent 18 years with the Canadian Ministry of Agriculture in various capacities as an economist, policy advisor and Director of Strategic Planning before joining the OECD 1993. He has worked in several different areas within the OECD Trade and Agriculture Directorate including policy monitoring and evaluation, food safety regulatory issues and agricultural development. He currently heads the Agro-Food Trade and Markets Division, responsible for the Secretariat's medium-term agricultural outlook as well as its analysis of various agricultural and trade policy issues.

ROLF JÖRDENS

Rolf Jördens obtained a diploma in agricultural economics from the University of Stuttgart-Hohenheim, Germany and a doctorate from the same Institute, followed by a two-year research position at the Institut National Agronomique in Paris, France. From July 2000 he has been Vice Secretary-General, International Union for the Protection of New Varieties of Plants (UPOV). Previous positions included the presidency of the German Federal Office of Plant Varieties (Bundessortenamt), Hanover, Germany from July 1997 to June 2000, with overall responsibility for variety testing, plant breeders' rights and listing of varieties. He occupied various positions in the German Federal Ministry of Food, Agriculture and Forestry, and worked in the Office of the Federal Chancellor from May 1976 to July 1997. He is a member of the Royal Swedish Academy of Agriculture and Forestry and the German Society of Agriculture (DLG).

JOHN KEDERA

John Kedera holds a PhD (plant pathology-minor plant breeding). From May 1997 he has been Managing Director of the Kenya Plant Health Inspectorate Service (KEPHIS). KEPHIS is a state corporation mandated to undertake plant protection, plant variety protection, seed certification, fertilizer, soil, water and pesticide formulation and residue analysis including environmental monitoring. From 2006 to 2008 he chaired the Commission on Phytosanitary Measures (CPM), a global forum taking decisions on phytosanitary issues and in particular the development and adoption of International Standards for Phytosanitary Measures (ISPMs) and he is currently Vice-Chairman. From 2006 to 2008 he chaired the Annual Meetings of the OECD Seed Schemes, where he is currently Vice-Chairman. These Schemes provide an international framework for the certification of agricultural seed movement in international trade. He has been a member of the Central Advisory Service Board to the CGIAR on Intellectual Property Rights since 1999 and is also Chairman of the Kenya National Taskforce on Horticulture.

CHANG HYUN KIM

Chang Hyun Kim is Director General of the Korea Seed and Variety Service (KSVS) of the Ministry for Food, Agriculture, Forestry and Fisheries (MIFAFF). He obtained a BA degree from the Department of Agricultural Education, Seoul National University in 1979 and an MA degree from the Department of Agricultural Economics at Ohio State University in 1992. He has served as Director of the Quarantine Planning Division, National Plant Quarantine Service (NPQS), MIFAFF; Director, General Division of International Cooperation at the International Agriculture Bureau, MIFAFF; Agricultural Attaché, Embassy of the Republic of Korea to the FAO, Ministry of Foreign Affairs and Trade; Director at the Office for Government Policy Coordination; Director of the Plant Variety Protection and Variety Testing Divisions at the Korea Seed and Variety Service.

JOEP LAMBALK

Joep Lambalk holds a degree in plant biochemistry and plant molecular biology from the Free University of Amsterdam. Upon graduation in 1987 he started work with Enza Zaden as their first plant biotechnology researcher. After a career of more than 22 years with the company he is currently Managing Director for Research and Development.

MICHAEL LARINDE

Michael Larinde is Senior Officer (Seed Production), Plant Production and Protection Division, FAO, Rome. He obtained a BSc. in agricultural biology from the University of Ibadan, Nigeria and an MSc. and PhD in agronomy/seed technology from Mississippi State University, US. He worked for 12 years with the West Africa Rice Development Association (WARDA), Monrovia, Liberia as the Officer-in-Charge of the WARDA regional seed laboratory and had key responsibilities for rice germplasm exchange between WARDA and various international centers and countries as well as conducting yearly seed training courses for participants drawn from 14 WARDA member countries. He joined the FAO 21 years ago and has held progressively responsible positions – first as Chief Technical Advisor (CTA) of the Guyana Seed Project (1987 to 1992); from 1992 to 1997 he was the CTA of the regional seed project for the 14 Island Countries of the Caribbean, during which period he was responsible for advising the governments of CARICOM on issues related to the seed industry. During these periods, he was involved in the development of the seed program of the 14 CARICOM countries and for providing training in different areas of seed program development. From 1998 to date, he has worked in the Seed and Plant Genetic Resources Service of FAO, Rome, where he offers extensive services and consultations to FAO member countries at global level. From 2002 to date he has been the FAO contact point with major international organizations dealing with seed.

BERNARD LE BUANEC

Bernard Le Buanec was born in 1943 and is an engineer in agronomy, having studied at the French Institute, Paris-Grignon. He has an MSc. in Soil Science and a PhD in Plant Biology. After 10 years in public research as an agronomist in several African countries he joined the Group Limagrain seed company in 1976, where he worked in various posts. When he left Group Limagrain in 1993 he was Corporate Research Director. In 1993 he joined the International Association of Plant Breeders (ASSINSEL) and the International Seed Trade Federation (ISF) as Secretary General. He organized the merger of the two organizations into the International Seed Federation (ISF) in 2002 and remained Secretary General of that organization until 2008 when he retired. Bernard Le Buanec is a member of the French Academy of Agriculture and a founding Member of the French Academy of Technology.

JOËL LÉCHAPPÉ

Joël Lechappé graduated from the Universities of Nantes and Rennes, France in botany, zoology, ecology, biochemistry and plant physiology in 1981. He gained a PhD in plant pathology (root diseases on Phaseolus) in 1986 from the University of Rennes . Joining INRA (National Institute for Agronomical Research) in 1987 in the Group for Study and Control of Varieties and Seeds (GEVES), he started his career as head of the Germination Laboratory of the National Seed Testing Station. He made contact with ISTA in 1987 with Professor Lennart Kåhre in Uppsala and since then he has contributed to ISTA's work via the Germination, Proficiency Test, Vigor and Rules Committees. His current interests are in seed quality, involving technical, applied research and regulatory aspects. The post of Technical Auditor for accreditation bodies such as UKAS, UK or forming part of the ISTA team of technical auditors offers him a great opportunity to learn and exchange views on the situation in the seed world. He has been Director of the National Seed Testing Station (SNES-Angers-France) since 1993 and a Member of the Executive Committee of ISTA since 2001.

PÄIVI MANNERKORPI

Ms. Päivi Mannerkorpi is an agricultural engineer with a PhD awarded in 1990 in animal nutrition from the University of Kiel, Germany. She worked on research in animal and grassland production at the Agricultural Research Centre of Finland from 1991 to 1994; she was Senior Officer and head of the Animal Nutrition Section at the Ministry for Agriculture and Forestry, Finland from 1994 to 2001. She headed the Policy and Legislative Unit including performance guidance of control authorities (animal nutrition and plant production including organic agriculture and biotechnology) at the Ministry for Agriculture and Forestry, Finland from 2001 to 2004 and she joined the European Commission, Directorate-General on Health and Consumers in 2004 as policy officer (EU legislation and policies on GMOs, novel foods, cloning, nanotechnology). Since 2008 she has headed the Material for Plant Reproduction in Unit Biotechnology and Plant Health Sector.

MICHAEL MUSCHICK

Michael Muschick is an agricultural biologist from the University of Stuttgart-Hohenheim, Germany. He holds a master's degree in biotechnology and a PhD in plant biochemistry from the ETH Zurich, Switzerland. After working on developing aid projects in Africa and research projects in plant breeding in Switzerland, he joined the International Seed Testing Association (ISTA) as Executive Officer in 1999 and became Secretary General in 2001. He was a member of the organizing committee of the 1st World Seed Conference in Cambridge, UK in 1999.

WILLIAM NIEBUR

As DuPont Vice-President for Crop Genetics Research and Development at Pioneer Hi-Bred International, William Niebur drives worldwide crop genetic research strategies to create new values for seed and agricultural value chain customers through advanced plant genetics. He has extensive global experience in plant genetics and biotechnology, having served in research director positions in both the US and Europe. In his current role he has been instrumental in integrating two new and proprietary technologies, gene shuffling and marker-assisted selection, into DuPont's plant genetics product development. During his 25-year career with Pioneer, he has been granted several patents that have led to the commercialization of more than 30 Pioneer® brand products. He has been instrumental in negotiating international research collaborations as well as the 2004 acquisition of Verdia. He holds BSc. and MSc. degrees from Iowa State University and earned his doctorate in plant breeding and cytogenetics from the University of Minnesota, US. In 2006, he was appointed Chair of the Private Sector Committee of the Consultative Group on International Agricultural Research, an organization that works to achieve sustainable food security and reduce poverty in developing countries through scientific research.

SHIVAJI PANDEY

Shivaji Pandey was born and raised in India. He obtained his MS and PhD in plant breeding and plant genetics from the University of Wisconsin, US and worked for over 30 years in international agricultural research and development, serving as a scientist, Regional Representative for South America, Director of the Maize Program and Director of the African Livelihoods Program at the International Maize and Wheat Improvement Center (CIMMYT) in Mexico and in its outreach programs. In 2005, he joined FAO as Director of Agricultural Support Systems Division (AGS). In 2006, he was appointed Director of their Plant Production and Protection Division (AGP) to lead work on increasing production and quality of all food and non-food crops to enhance food security and livelihoods especially of the rural and urban poor. The work of the Division involves conservation and sustainable use of plant genetic resources, seed production, development and deployment of improved cultivars, use of appropriate agronomic practices, cropping systems, conservation agriculture, organic farming and integrated pest management, etc. International treaties and commissions such as IT PGRFA, GPA (Global Plan of Action), IPPC (International Plant Protection Commission), International Code of Conduct on Pesticides and the Rotterdam Convention also form part of the Division's work. He chairs the Inter-Departmental Working Group on Biotechnology at FAO which integrates the research, development, and policy work on biotechnology of the Organization for agriculture, forestry and fisheries. Honors and awards received include a DSc. from the Maharana Pratap University of Agriculture and Technology, India. He is also a Fellow of the American Society of Agronomy; a Fellow of the Crop Science Society of America and has received special recognitions from the governments of Bolivia, Colombia, Ecuador and Vietnam. He has authored or co-authored over 150 publications.

ALISON POWELL

Dr. Alison Powell began her work on seed quality during her PhD, working on the physiological basis of seed quality in Pisum sativum (garden pea). This basic research was extended to a wide range of temperate and tropical grain legumes and small seeded vegetable species during her career in teaching and research at the universities of Stirling and Aberdeen in Scotland. Much of her research has been in collaboration with postgraduate students and visiting scientists from Asia, Africa and South America as well as Europe. Taking research from science into practical use has been an important aspect of her work. One practical outcome was the electrical conductivity test for peas becoming one of the first two vigour tests to enter the ISTA Rules. This will be followed by the application of the test to Phaseolus beans and soybeans. Recently, along with colleagues in the ISTA Vigour Committee, which she chairs, she has guided the controlled deterioration vigour test for Brassica species into the ISTA Rules. The physiological basis of these tests is supported by her extensive publications in international journals. She has retired from her post at the University of Aberdeen and was awarded a DSc. in 2005 in acknowledgement of her research contribution to seed science. She is a member of the ISTA Executive Committee and has been on the Editorial Board of three international plant science journals (Annals of Botany, Journal of Experimental Botany, Seed Science and Technology) for many years. Since 2002, she has been the Seed Symposium Convenor for the triennial ISTA Congress, which will next be held in Cologne, Germany in June, 2010.

MICHAEL RYAN

Michael Ryan holds a PhD in agricultural economics (international trade and finance) from the University of Alberta, Edmonton, Canada, and an MAgrSc. from University College Dublin, Republic of Ireland. Prior to joining OECD in 1992, Mr. Ryan worked as an agricultural policy analyst in the Canadian Ministry of Agriculture. Since that date he has been responsible for completing several agricultural policy reviews, has regularly contributed to the OECD Annual Monitoring Report of Agricultural Policies, and has led the work under the Baltic Regional Programme and the South East Asia Programme. In addition, he was team leader of the project on examining the policy impacts of modern biotechnology in developing countries. Michael Ryan was appointed head of the OECD Codes and Schemes in 2006.

EVANS SIKINYI

Evans Sikinyi is the head of Seed Certification and Plant Variety Protection at The Kenya Plant Health Inspectorate Service (KEPHIS). He holds a PhD degree from Iowa State University in horticulture (breeding and biotechnology), an MSc. in plant breeding and a BSc. in agriculture from the University of Nairobi. He has been key in setting up and operating the plant variety protection system in Kenya. He trained in intellectual property inter alia at Michigan State University; Cambridge, UK; WIPO/UPOV, Geneva; and the United States Patent and Trademark Office (USPTO). He is a qualified trainer in intellectual property (USPTO Global Intellectual Property Academy) particularly relating to plant variety protection. He was a key member of the task force that recently developed the seed policy for Kenya and the Vice-Chair of the task force for developing policy and laws for traditional knowledge, genetic resources and folklore in Kenya. He is a member of the Expert Advisory Committee of the Central Advisory Service on Intellectual Property for the CGIAR and is the leader of Kenya's delegation to the International Treaty on Plant Genetic Resources for Food and Agriculture. He is a member of the UPOV Council, Administrative and Legal and Technical committees and also a member of various technical working parties in UPOV. He chaired the UPOV study on the impact of plant variety protection.

M. S. SWAMINATHAN

Professor M. S. Swaminathan has been acclaimed by Time magazine as one of the 20 most influential Asians of the 20th century and one of only three from India, the other two being Mahatma Gandhi and Rabindranath Tagore. He has been described by the United Nations Environment Programme as the father of economic ecology and by Javier Perez de Cuellar, Secretary General of the United Nations, as "a living legend who will go into the annals of history as a world scientist of rare distinction". He was Chairman of the UN Science Advisory Committee set up in 1980 to follow up on the Vienna Plan of Action. He has also served as Independent Chairman of the FAO Council and President of the International Union for the Conservation of Nature and Natural Resources. He served as President of the Pugwash Conferences on Science and World Affairs (2002 to 2007) and President of the National Academy of Agricultural Sciences (2005 to 2007). A plant geneticist by training, Professor Swaminathan's contributions to the agricultural renaissance of India have led to his being widely referred to as the scientific leader of the green revolution movement. His advocacy of sustainable agriculture leading to an ever-green revolution makes him an acknowledged world leader in the field of sustainable food security. The International Association of Women and Development conferred on him the first international award for significant contributions to promoting the knowledge, skill, and technological empowerment of women in agriculture and for his pioneering role in mainstreaming gender considerations in agriculture and rural development.

Professor Swaminathan was awarded the Ramon Magsaysay Award for Community Leadership in 1971; the Albert Einstein World Science Award in 1986; the first World Food Prize in 1987; the Volvo and Tyler Prize for Environment; the Indira Gandhi Prize for Peace, Disarmament and Development in 2000 and the Franklin D. Roosevelt Four Freedoms Medal and the Mahatma Gandhi Prize from UNESCO in 2000. Professor Swaminathan is a Fellow of many of the leading scientific academies of India and the world, including the Royal Society of London and the US National Academy of Sciences. He has received 58 honorary doctorates from universities around the world. He currently holds the UNESCO Chair in Eco-technology at the M. S. Swaminathan Research Foundation in Chennai, India and was formerly Chairman of the National Commission on Farmers in the Government of India. He is currently a Member of the Parliament of India (Rajya Sabha), to which position he was nominated in May, 2007 by the Government of India in recognition of his contribution in the field of agricultural research and development. He was awarded the Padma Shri (1966), Padma Bhushan (1972) and the Padma Vibhushan (1989) by the President of India. Professor Swaminathan served as Director of the Indian Agricultural Research Institute, New Delhi from 1966 to 1972; Director General of the Indian Council of Agricultural Research and Secretary to the Government of India, Department of Agricultural Research and Education from 1972 to 1979; Principal Secretary at the Ministry of Agriculture from 1979 to 1980; Acting Deputy Chairman and later Member of the Union Planning Commission from 1980 to 1982 and Director General of the International Rice Research Institute in the Philippines from1982 to 1988. He currently holds the UNESCO Chair in Eco-technology and is Chairman of the M. S. Swaminathan Research Foundation, Chennai, India.

YLVA TILANDER

Dr. Ylva Tilander has been Deputy Director of the Animal and Food Division of the Ministry of Agriculture in Sweden since 2004. She is responsible for coordinating international negotiations related to plant genetic resources and overall budget and planning processes. She headed the Swedish team on genetic resources during the Swedish EU Presidency in the autumn of 2009 and she also chairs the board of the Nordic Genetic Resource Center. She was previously, Senior Adviser to the Nordic Council of Ministers (Fishery, Agriculture, Forestry and Food Affairs) for policy development in the field of agriculture, forestry and food security and has provided information services to the Swedish Energy Research Commission. A writer on the environment, science and development questions for several Swedish newspapers, she holds a PhD in ecology and environmental sciences, with a specialization in ecological competition and sustainable resource use in semi-arid agro-forestry from the Swedish University for Agricultural Sciences. She has also participated in fieldwork in Burkina Faso, Tunisia and India.

ANKE VAN DEN HURK

Ms. Anke Van den Hurk has been a senior adviser at Plantum NL, the Dutch association for breeding, tissue culture, production and trade of seeds and young plants, since 2001. She is a specialist in the field of biodiversity, in particular access and benefit sharing (ABS), participating in the various meetings of the IT PGRFA and the Convention on Biological Diversity (CBD) as a representative of the breeding sector. She represents the sector in the various industry fora dealing with ABS, such as the International Seed Federation, the European Seed Association, CIOPORA, the International Chamber of Commerce. Within ISF she chairs the working group on biodiversity. Before joining Plantum NL she worked from 1996 to 2001 at the International Plant Genetic Resources Institute (IPGRI) now known as Bioversity International, in Rome and Cali, Colombia as associate expert on training in plant genetic resources and on complementary conservation strategies. From 1995 to 1996 she taught various agricultural subjects including plant breeding at Mekelle University College in Ethiopia. From 1992 to 1995 Anke Van den Hurk worked as a vegetable breeder at Nunhems Zaden in the Netherlands. She holds an MSc. degree in plant breeding from the Wageningen University and has worked on taxonomy, plant breeding in Ethiopian barley landraces and growth models.

JOOST VAN DER BURG

Alumnus of Wageningen University, Joost van der Burg started his professional career at the government Seed Testing Station in Wageningen, Netherlands, as head of several departments. During this period he contributed extensively to the development of the International Rules for Seed Testing (the ISTA Rules). Ten years later he moved to the position of Leader of the Seed Technology Section during which he was involved at the start of some of the developments such as non-destructive quality determination of seeds. During his career he has traveled extensively in temperate and tropical countries. Over the last decade he has been responsible for a number of research and development programmes and projects to support agriculture and horticulture in developing countries many of which involved seed quality, seed production and legislation. Joost van der Burg is currently the Netherlands' official representative at ISTA and member of the ISTA Advanced Technologies Committee. He is Senior Seed Scientist and Tropical Botanist at Plant Research International in Wageningen.

BERT VISSER

Bert Visser was born in the Netherlands in 1951. He obtained an MSc. degree in Molecular Sciences at Wageningen University in 1976 and in 1982 obtained a PhD at the University of Utrecht in the Netherlands in the area of medical virology. He then worked in the Agricultural Research Department of the Ministry of Agriculture, Nature and Food Quality as a plant biotechnologist. In 1992 he joined the Ministry of Foreign Affairs as a senior officer in the Special Programme Biotechnology and Development Cooperation, where he is in particular responsible for capacity building. Since 1997 he has been Director of the Centre for Genetic Resources, the Netherlands (CGN), which - under its own mandate - is part of Wageningen University and Research Centre. As the Director of CGN he fulfils an advisory role for the Ministry of Agriculture, Nature and Food Quality on policies regarding (agro-)biodiversity. In this capacity he has been a regular member of the delegations to FAO and the CBD. Furthermore he functions as the national focal point for the implementation of the Global Plan of Action on PGRFA, and has been appointed as the National Focal Point on Access and Benefit Sharing of the CBD. His interests and activities concern genetic resource management and policy development, international collaboration in the area of genetic resource management, on-farm conservation of genetic resources and the interface of agro-biodiversity and biotechnology.

DOUG WATERHOUSE:

Doug Waterhouse is a graduate in botany and forestry from the Australian National University where he specialized in quantitative genetics. His research career began in the Research School of Biological Sciences, where he worked on the forerunner to "climate change". In 1978 he moved to the Department of Agriculture as part of the Lucerne Breeding Team and released the widely acclaimed series of varieties starting with 'Nova', 'Aurora' and 'Aquarius'. In the 1990s he turned his attention to conservation issues and joined the then Department of Conservation and Land Management to direct their programs related to revegetation and salinity control including work on developing more than 100 native and introduced species for land and water reclamation. After a period as the senior examiner, he has for the last 15 years been Chief of the Australian Plant Breeder's Rights scheme and the Chairman of the Plant Breeder's Rights Advisory Committee. He has been a regular participant in UPOV's Technical Committee and is current President of the UPOV Council.

RITA ZECCHINELLI

Ms. Rita Zecchinelli is from Italy. She graduated at the University of Milan in agricultural science with a degree thesis on seed germination physiology. In 1985, she joined the Ente Nazionale Sementi Elette (ENSE), the Italian public body which carries out seed certification on behalf of the Ministry of Agriculture and Forestry. She has been working in the Seed Certification Unit in Milan for 13 years, being involved in field inspections, seed sampling and other tasks related to seed certification in different species (cereals and forage crops in particular). In 1998, she moved to the Seed Testing Laboratory in Tavazzano, becoming the head of the station and still holds the same post. As head of the laboratory, she is engaged in seed testing, including traditional tests such as germination, purity, moisture content determination, variety and GMO tests, all of which are at present included in the laboratory's scope of ISTA accreditation received in 2000. The laboratory is also a member of the ENGL (European Network for GMO Laboratories). At national and international level, Rita Zecchinelli has been and is a member of different committees and boards working on subjects related to seed certification and seed testing. She has been a member of the Executive Committee of ISTA since 2004 and of two ISTA technical committees (the Proficiency Test Committee and the Flower Seed Committee). As Vice-Chair of the Flower Seed Committee, she is co-editor of the ISTA Handbook for Flower Seed Testing, published in 2008. Since 2006 Rita Zecchinelli has also been an ISTA technical auditor.

PARTICIPANT LIST

Nom	*Prenom*	*Company*	*Country*
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