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PLANT VARIETY PROTECTION

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NEWSLETTER

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PLANT BREEDING ACTIVITIES OF GOVERNMENT INSTITUTES, INTERNATIONAL CENTERS AND THE PRIVATE SECTOR

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PLANT BREEDING AT THE FRENCH NATIONAL INSTITUTE OF AGRONOMIC RESEARCH (INRA)

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Summary

Plant breeding is an area of scientific research and an economic activity at the same time.

It is an area of scientific research in that it develops the technology and methods whereby, on the one hand, optimum use may be made of investment in plant breeding (in the short and medium terms) and, on the other hand, the genetic variability of a species may be preserved and managed (in the long term).

It is an economic activity in that it makes genetic progress available to the national community (and even the international community) by way of plant breeding.

These two aspects of plant breeding are mutually stimulating.

In countries engaged in significant plant breeding activity, basic research and plant breeding are taken care of either by the same body or by different bodies.

In countries that have a private breeding industry, including certain firms with substantial resources, the dividing line between research and plant breeding is far from clear. This is true of the Federal Republic of Germany, the Netherlands, the United Kingdom and the United States of America, to give just a few examples.

It is also true of France; the relations between Government-sponsored research and private breeding establishments in France are described and analyzed here in their national and international contexts.

It is thus for me to begin the day's work with an exposé on the plant breeding work of Governmental institutes. When completed by the exposés of the next two speakers after me, it will, at least I hope it will, provide material for a wide-ranging exchange of views on the relations between Government-sponsored research, private breeding and international plant breeding centers.

All countries that have an agricultural vocation have provided themselves with Governmental plant breeding institutes. This is because all the political decision-makers have acknowledged the importance of the variety factor in an agricultural economy.

We French now speak of "pouvoir variétal" as we once spoke of "pétrole vert" to denote agricultural potential.

At the back of these metaphorical exercises there is an agronomic and economic reality: increases in yield, the year-to-year regularity of production, the introduction of a species in areas where it has not yet been grown and the qualitative improvement of products owe much to the genetic progress represented by the breeding of higher-performance varieties.

For instance, we in France consider that the increase in average soft wheat output (25 quintals in the course of the last 20 years) is attributable half to genetic progress (that is, 0.7 quintal per hectare per annum) and half to progress in growing techniques.

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We could also mention the introduction of maize (grain and silage) in northern areas with short growing periods, made possible by the breeding of early hybrids. Finally I would mention the magnificent work done on rapeseed by geneticists, who first improved the quality of the oil (breeding of "0" varieties without erucic acid) and then that of the oil cake (breeding of "0.0" varieties with a very low goitrogen content).

I shall not force other examples on you. Each one is as convincing as the next.

This creative activity has naturally given rise to a veritable seed industry for the multiplication, packing and marketing of seeds, including export in the case of certain countries.

The turnover of the seed industry is considerable, apart from which it provides jobs and will continue to do so, as in this area mechanization and automation will replace human intervention only to a very small extent.

With the exception of the Socialist countries, in which the seed industry is exclusively a State operation, plant breeding is taken care of by two categories of operators: Government establishments and private establishments. The relative oldness and size of the two categories and their relations, that is, the way in which they share out the work, have resulted in widely differing situations from country to country.

In the United Kingdom for instance, it was not until 1965 that the first private plant breeding activity of any significance was noted. The first privately-developed plant varieties were put on the market in 1975. Since then the activity has grown in scale and has even brought in multinational firms. However, the Government institutes do still have a dominant position, and one can fairly speak of competition between them and private establishments.

A few steps away from the United Kingdom, the Netherlands provide us with a completely different example. In this country, with its ancient tradition of breeding work in horticultural crops and staple food crops, backed up by a no less ancient tradition of international trading, the Government institutes have deliberately opted for complementary relations, setting themselves at an earlier point in the development chain than the private establishments and providing them with technology, methods and more or less highly developed plant material, according to rules that entail the selection of establishments and supervision of their technical orientation. With few exceptions, the Government institutes do not release commercial varieties. Relations with the private establishments are therefore very good, and all the more so since Dutch researchers do protect their breeding firms by deferring the dissemination of their material abroad for a sufficiently long time.

Clearly then it is impossible to speak of plant breeding activities in Government institutes or universities without taking their relations with private establishments into account.

It is in the this light that I intend to give a brief account of the situation in my country.

In France, Government plant breeding work is mainly carried out by the National Institute of Agronomic Research (INRA). Alongside INRA there are a number of bodies specialized in species from tropical and equatorial areas (ground nuts, coffee, cotton, sugar cane, date palm, etc.). Finally the National Center for Scientific Research (CNRS) and the laboratories of universities and graduate schools specialized in agronomy contribute to the increase in our knowledge of biology and methodology.

The Genetics and Plant Breeding Department of INRA alone comprises nearly 200 researchers distributed over 25 stations and engaged on the breeding of 70 species, some of them grown in climatic circumstances that are very different from north to south (straw crops, maize, fodder plants). This research department, which was set up in about 1930, did not see any significant growth in its resources and programs until after the second world war.

Opposite this there is a substantial seed industry, including some very long-established firms (I take the liberty of mentioning de Vilmorin). It is a multifarious collection of family firms, cooperatives, nationalized firms and multinationals, which vary widely in turnover, potential for plant breeding and financial participation by foreign firms. It is also a conglomeration characterized by intense competition within itself. It is very difficult to evaluate the investment that these private establishments make in plant breeding. One could as an indication suggest the figure of 150 researchers and agronomists and a turnover percentage ranging between 5% and 10%.

Under such circumstances, there is no question of our Plant Breeding Department competing with the private sector.

With regard to species on which private firms are working efficiently (maize, certain vegetables, potatoes, rapeseed), we have to increase their performance by means of more innovative basic research.

With regard to species where private-sector involvement is still insufficient, we have to contribute towards remedying the situation by means of more concentrated assistance in plant breeding. A typical example of this is the case of sugar beet. Soya is another example, but for other reasons.

Finally, with respect to other species, plant breeding is taken care of almost exclusively by INRA. This is the case of vine and fruit tree varieties and rootstocks. It is also true of vegetables neglected by private breeders, such as chicory, asparagus, artichoke and cultivated mushrooms.

Our Institute produces three categories of findings that are passed on to the seed industry:

- technology and methods;
- populations at varying stages of improvement; parent material: these are semi-finished products;
- commercial varieties, which are finished products.

Let us look more closely at the three categories of findings.

Technology and Methods

Plant breeding is a scientific discipline whose short-term purpose is the breeding of higher-performance varieties and its long-term purpose the intelligent exploitation of intraspecific and interspecific variability to support genetic progress. It draws on genetics, plant physiology, biochemistry and biometry.

It is also an economic activity, however, in that it entails working towards optimum yield on investment, in the sense of salary, land and time expenditure. Methodological research in plant breeding absolutely has to take this economic factor into account when it seeks to achieve maximum genetic progress per investment unit. This entails the design and testing of new crossing plans, the introduction of out-of-season growing and recourse to tissue culture to make use of the variability of the products of meiosis (androgenetic or gynogenetic), to produce variants and to carry out rapid identical multiplication to clone a genotype.

This also entails keeping a very close watch on the progress of genetic engineering in higher plants, even though we are quite aware of the considerable difficulties that have yet to be overcome.

However, this also requires preservation of the genetic variability without which the geneticist and the breeder are handicapped; indeed this is where the whole problem of genetic resources lies.

All this research is entirely within the terms of reference of our Institute and other Government laboratories. However, there is nothing to prevent private establishments from contributing, by means of complementary financing, the carrying out of experimental work and the supply of plant material to us.

Such collaboration already exists in France, and there will certainly be more.

All this technology and these methods have to be widely circulated and taught. They are not eligible for protection, neither must they be the subject of exclusive rights: they belong to the scientific community. There should be no departure from this rule, even if the technology and methods have benefited from financial aid on the part of certain firms--it is for them to secure the best advantages in the shortest possible time.

Basic Material, Parent Material

This first aspect of the plant breeding activities of a Government institute leads to the production of improved material in a semi-finished state which will require a greater or lesser number of sexual generations for a marketable variety to emerge. Every level of intermediate material exists between a basic population rich in interesting genes and subject to weak selection pressure and an improved parent with a resistance to a parasite that is controlled by a simple genetic mechanism.

Firms in possession of the former material will have a great deal of work to do to produce varieties which will probably be quite different from one firm to the next. Those that receive seed of the resistant parent will rapidly incorporate the characteristic in an improved line and will market products that are very similar. This is a situation well known to us in the case of certain vegetables.

INRA is more often than not faced with partners grouped in clubs, associations of breeders or economic interest groups. Such groups exist for practically all major species. In that case the assistance provided is the same for all the members of the club, whether they are French firms, French firms associated with foreign firms or foreign firms on their own. The authorities leave to the professionals the responsibility of determining the conditions for admission to the club.

However, we may also find ourselves entering into special agreements with a single firm (this is an exceptional situation, but one that does exist in the case of rapeseed) or with a small number of firms, for "one-off" collaboration on a specific project. Such collaboration may result in a joint variety. It is limited to French firms, an attitude which, while normal, does seem somewhat inconsistent with the policy we have adopted in relation to clubs.

We cannot leave this chapter on semi-finished material without mentioning relations with foreign institutes. Researchers have always exchanged plant material between themselves; it is in this way that they have set up their collections of varieties and parent material. By definition, such exchanges cannot be one-way: there is no receiving without giving. Today the economic stakes are such that a growing number of institutes are taking a more protectionist attitude. How are we to find the happy medium between this necessary collaboration between institutes in the exchange of semi-finished material and the preferential assistance that a Government insitute owes to private breeders who work on the national territory? In France we have directed ourselves more towards temporary exclusive rights (of three to five years' duration) granted to our own firms, the supply of the material to foreign breeders being delayed by the same period. That appears to be a good compromise.

Commercial Varieties

Between the parents mentioned above and commercial varieties there are lines that are used for crossing in the production of single cross, three-way cross and two-way cross hybrids. They are elibible for protection when the species itself is eligible, and so they do not present any particular problems of development and exploitation.

We do not regard it as the prime vocation of our Institute to breed commercial varieties. On the other hand it should not be banned from breeding, and indeed it is sometimes duty-bound to engage in it: this is because it substitutes for unsuccessful breeders, because it is intent on showing the value of a parent or method in the form of a new variety, or because it possesses a particularly interesting variety and has no right to deprive the national community of that variety. This means that the varieties we propose for inclusion in our official catalogue have to reflect genetic progress in their agronomic performance or in one or more original characteristics, which in turn presupposes that we know them quite well before marketing them. Having said this, we are bound to admit that reality is sometimes different. The main causes are the wide diversity of situations and the pressure of historical events.

Once we have taken the decision to multiply one of our plant varieties, we have to do our utmost to ensure that it is offered to farmers as rapidly as possible and on the best possible terms (volume of seeds or seedlings, quality of the material). As it is not our job to produce, pack and market seed, and as moreover we do not have an organization comparable to the National Seed Development Organization Ltd. (NSDO) in the United Kingdom, we have to find the most efficient partners available within the seed trade.

The best marketing strategy undoubtedly consists in entrusting the exclusive multiplication of the variety to a single person. We shall probably be doing this more and more often. For our purpose in this, as I said, is to give farmers, processors and consumers the benefit of the innovation.

I would add that royalties are entirely paid to the Institute itself, and not specifically to its Genetics and Plant Breeding Department.

It is now time for me to conclude.

I believe in the ability of plant breeding to enrich the present range of plant material with new varieties and no doubt with new species whose characteristics and performance will far exceed the hopes of the breeders of our generation. On the strength of this belief, I leave you with the following three thoughts.

Governments must invest in such research as permits genetic progress to be made. The interest of our various agricultural economies is at stake, as is agricultural production throughout the world. We should not forget that genetic progress, in the sense of new varieties, is almost a free gift for the farmer, and that it is the one progress that an agricultual enterprise can most readily accept and assimilate.

The seed industry is a means rather than an end. The fact that private breeding establishments are the privileged partners of Government plant breeding institutes is not solely due to the fact that they represent an important sector of the economy, but also, and above all, because it is through those establishments that we bring technical and social progress to farmers, industrialists and consumers. They are the real "clients" of our institutes.

While competition between firms and between nations is one of the rules of the game, we have yet to find a way of reconciling, in the medium term, the necessary protection of each country's private firms with the exchange of plant material between institutes, which have hitherto made a considerable contribution to genetic progress throughout the world.

[Translated from the French]

CIMMYT'S CROP IMPROVEMENT PROGRAMS

R.L. Paliwal and Arthur R. Klatt*

Summary

The International Maize and Wheat Improvement Center (CIMMYT) is a non-profit, autonomous agricultural research institute. It is part of a global network of 13 international agricultural research centers (IARCs) supported by the Consultative Group on International Agricultural Research (CGIAR). Nine of the centers have a commodity orientation, two are livestock-oriented, and two focus on agricultural policy and management issues.

The CGIAR is an informal group of donors, some 35 in number, that mobilizes financial support for the centers. These donors include individual governments, international agencies, and private foundations, with most support coming from public sector organizations. The CGIAR system mandate and criteria for international support require that the IARCs orient their research and training toward increasing the absolute availability of world food supplies, with particular emphasis on food production in the developing world. Further, IARC research activities must offer the potential of widespread benefits for food security, either regionally or globally, and address the production problems of low-income, food-deficient countries.

CIMMYT's mandate calls for it to support and complement the research efforts of developing countries to increase the quantity, dependability, and quality of maize, wheat, barley, and triticale production. Our mandate is global and involves virtually every maize- and wheat producing country in the world. Crop improvement is the primary research thrust, although CIMMYT provides a variety of services to national collaborators, including germplasm improvement, training programs, development of research procedures, information services, and consultation.

CIMMYT's maize and wheat programs adhere to several common philosophies in crop improvement. Both programs aim to develop a wide range of broadly adapted, input efficient and responsive germplasm which possesses high yield potential and enhanced yield stability conferred through genetic resistance and/or tolerance to major pests and agroclimatic stress problems.

While there are some differences in the improvement procedures followed in maize, a cross-pollinated crop, and wheat, a self-pollinated crop, both programs adhere to the principle of large-scale multilocational testing and selection in which national collaborators play a full partnership role. Materials exhibiting superior characters at many locations are used in future improvement activities, thus reinforcing useful traits in the germplasm distributed in successive testing cycles.

CIMMYT's international testing programs are structured in such a way that every national program--well established or just beginning--is able to utilize germplasm of potential benefit to its research efforts. The extensive observations and measurements made by collaborators in the international networks are critical to the development of widely adapted materials of potential benefit in many production environments. To serve this network, CIMMYT conducts extensive breeding programs at different locations in Mexico which are representative of the agroclimatic conditions found in many areas of the developing world. It also supports special collaborative research efforts with selected national programs to develop materials with greater resistance to specific diseases and/or insects, and with greater tolerance to problem soils and other important agroclimatic stress problems.

Although CIMMYT acts as the hub in the development, assembly, distribution, and data analysis of the early and advanced generation breeding materials included each year in the various international trials and nurseries, it neither names nor releases varieties. This is the responsibility of cooperating national programs.

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CIMMYT has historically shared germplasm with any bonafide scientist or research organization. It does, however, follow certain guidelines and priorities, since requests for seed are greater than the material available. First priority goes to collaborators in national research programs and universities in developing countries, second priority to public institutions in developed countries, third priority to private institutions. These materials and services are provided free of charge.

The CIMMYT-coordinated international maize and wheat improvement networks, based on a free and essentially unrestricted exchange of germplasm, have served as a unifying thread to bring together the work of thousands of scientists and hundreds of organizations worldwide. As a result of this collaboration, hundreds of high-yielding maize and wheat varieties with broad adaptation and increasing levels of yield dependability have been released in both developing and developed countries. They are grown today on millions of hectares and have played a major role in the dramatic increases achieved in world cereal production in recent years.

Introduction

CIMMYT, the International Maize and Wheat Improvement Center, is a non-profit, autonomous agricultural research institution dedicated to supporting and complementing the research efforts of developing countries to increase the quantity, dependability, and quality of maize, wheat, barley, and triticale production. CIMMYT's mandate is global and involves virtually every maize- and wheat-producing country in the world.

CIMMYT is a part of a global network of 13 international agricultural research centers (IARCs) supported by the Consultative Group on International Agricultural Research (CGIAR). This body is an informal group of donors, some 35 in number, that mobilizes financial support for the centers. Donors include private foundations, individual governments, and international agencies, with most of the pledges coming from public sector organizations.

The IARC network includes a range of different types of institutes. Eight of the centers have a commodity orientation, and work on the major food crops grown in the developing world. Some of the institutes concentrate on tropical and subtropical production areas while others are more concerned with semi-arid and arid regions. Two centers, both located in Africa, are livestock-oriented research institutes that focus on African livestock diseases and production systems. One center is concerned with world food policy problems and another with management issues related to agricultural research systems in the developing world. Finally, the International Board for Plant Genetic Resources (IBPGR) was established in 1974 to conserve irreplaceable sources of valuable genetic material represented by the primitive cultivars of crop species and their wild relatives. (See figure 1)

Each of the international centers is an autonomous agricultural research, training, and technical assistance institute staffed by an internationally recruited staff and governed by an international and non-political board of trustees. Despite the autonomy of each center, the CGIAR does use certain criteria to justify support to IARC research activities. In general, the IARCs are required to orient their research, training, and technical assistance activities toward increasing the absolute availability of world food supplies, with particular emphasis on food production in the developing world. Further, these research activities must offer the potential of widespread benefits for food security, either regionally or globally, and must address the production problems of low-income, food-deficient countries.

Since the inception of the CGIAR in 1971, the number of CGIAR-supported centers has grown from four to 13, with more than 20 crops now receiving research attention (see table 1). To date, the most significant impacts from IARC research have occurred in wheat and rice production. The results emerging from many other of the newer IARC research activities indicate that breakthroughs are on the horizon for a number of other vitally important food crops.

CIMMYT's Relationships with National Programs

Currently, there are 53 countries with more than 100,000 hectares planted to maize and 27 countries with more than 100,000 hectares planted to wheat in the developing world. CIMMYT is closely involved in a number of ways with these major maize- and wheat-producing countries as well as with dozens of other countries where maize and wheat are important crops, although the area currently devoted to them is not very large.

CIMMYT has a number of active programs which are designed to support and strengthen the research capacities of national maize and wheat programs in the developing world. These contributions fall in the following general categories:

(1) Improved germplasm;

(2) Training and staff development programs;

(3) Procedures for crop improvement and production research;

(4) Information services; and

(5) Consultation assistance.

Germplasm Development

The development of improved germplasm is one of our most important activities. While there are some differences in the crop improvement procedures followed by CIMMYT scientists in maize, a cross-pollinated crop, and wheat, a self-pollinated crop, both programs adhere to the principle of large-scale multilocational testing and selection networks in which national collaborators play a full partnership role. Both programs seek to develop superior genetic materials with broad adaptability and dependability of yield across many locations. National collaborators focus on selecting materials and developing varieties that have the best adaptation to local conditions.

Training and Staff Development

CIMMYT's in-service training programs, support of visiting scientists, and pre- and post-doctoral fellowships are extremely important activities for the fulfillment of our mandate. Without growing cadres of trained national scientists engaged in well-focused research activities, the value and impact of improved germplasm cannot be realized. Each year, CIMMYT receives some 120 in-service trainees and 50 to 60 visiting and associate scientists from about 50 developing countries. These scientists stay at CIMMYT from one month to one year, with most in-service trainees staying six months--one full crop season. Another 10 to 15 individuals are in residence at CIMMYT each year as pre- and post-doctoral fellows. This alumni network now includes more than 2,500 individuals from over 70 countries.

Development of Research Procedures

CIMMYT trainees and visitors are exposed to the many research procedures which have been developed by CIMMYT scientists and national collaborators over the years. These procedures have emerged either from CIMMYT's own efforts to make its field techniques more efficient or through conscious efforts to develop appropriate sets of research methodologies for use by national collaborators. Many such research procedures are in use today in crop improvement and production programs around the world.

Information Services

CIMMYT also prepares a number of publications each year for distribution to collaborators and other interested parties. Some publications deal directly with germplasm improvement and other with research procedures and policy-related issues. These publications are valuable tools in the diffusion of improved technology.

Consultation

Finally, given the broad experience of the CIMMYT staff in maize and wheat research and production, many national programs call on us for counsel on the organization of maize and wheat research and on ways to address the constraints limiting production in their countries. One of the distinguishing concepts in CIMMYT's consultation work is our commitment to the integration of various disciplines from the earliest stages under experimental conditions to the verification of recommendations at the farm level and the final diffusion of the technology to the farmer.

CIMMYT'S Crop Improvement Programs

CIMMYT has established germplasm collections for maize, wheat, barley and triticale as service units for researchers worldwide. These service units maintain, catalogue, and regenerate seed, and handle special seed requests and shipments to users. The maize germplasm bank contains more than 13,000 entries in cold storage, gathered from over 50 countries. A new, recently completed wheat germplasm storage facility contains a broad range of CIMMYT wheat, barley, and triticale germplasm in sufficient quantities to supply small-scale seed increases for other collaborating programs.

CIMMYT's breeding work begins in Mexico on a number of experiment stations located in different climatic areas. These stations range in altitude from near sea level to 2,600 meters and in latitude from 18° to 28° North. Such a range of production conditions permits CIMMYT to conduct two breeding cycles per year as well as to make preliminary progress towards identifying and developing broadly adapted, high-yielding germplasm with enhanced dependability of yield. When this range of germplasm reaches sufficient levels of improvement to be of use to collaborating national scientists, such materials become entries in the dozens of different nurseries available for international testing and offered free of charge to collaborators in more than 120 countries. Each year, well over one million packets of seed are assembled into many different nursery sets for international testing at hundreds of locations worldwide.

Maize Improvement Program

CIMMYT's efforts in maize improvement are directed toward the development and maintenance of broad-based gene pools and populations leading to the development of superior open-pollinated varieties.

Yield-Dependability--Particular attention is being paid to increasing the disease and insect resistance, tolerance to agroclimatic stresses, and wide adaptability of the CIMMYT materials--all important factors for increasing yield dependability.

For disease resistance, populations grown in Mexico are artificially inoculated with stalk- and ear-rotting organisms. For leaf blights and rusts, we rely on naturally occurring infestations. For insect resistance, we infest our populations with the larvae of those insects found in Mexico which are important maize pests in other parts of the world.

We are also involved in several collaborative disease research projects which cannot be handled from Mexico. These disease research projects are focused on: downy mildew, caused by a fungus found mainly in South and Southeast Asia, but now spreading to Africa and Latin America; maize streak virus, disseminated by a leaf hopper throughout tropical Africa; and corn stunt, a disease also spread by leaf hopper throughout tropical Latin America. The centers of activity in these disease research projects are in the various affected areas. Our regionally assigned staff, working closely with national collaborators, carry the principal responsibility for CIMMYT's involvement in such research.

Grain Efficiency--Generally speaking, tropical maize plants are very tall, leafy, have a large tassel, do not make efficient use of fertilizer and space, and often have a tendency to fall over at maturity. Within the tall tropical maize plant, a relatively greater part of the energy goes into the foliage and tassel, rather than grain. To overcome these limitations, CIMMYT has been putting considerable emphasis on reducing plant height, leaf area, and tassel size, while selecting for yield and other desirable agronomic characters. CIMMYT is now providing national programs with shorter, more manageable, fertilizer-responsive tropical maize plants, with the potential of greater grain yield per hectare. We hope that one day tropical maize will be very close in yield potential to temperate maize, which is a more efficient producer of grain.

Tolerance to Agroclimatic Stress--We are also placing increasing emphasis on enhancing the tolerance of the CIMMYT materials to agroclimatic stresses. Two major approaches are being pursued. One involves selection within our wide range of pools and populations for materials which exhibit greater tolerance to stress situations, including drought, a very important problem in the tropical areas. We are also exploring the possibility in our wide cross program of transferring genes into maize from alien genera to confer greater environmental stability. At present, we are working on maize x sorghum crosses with the hope of transferring sorghum's tolerance to drought and waterlogging to maize. Our crossing program with maize x *Tripsacum* is directed toward transferring *Tripsacum*'s tolerance to certain diseases and insects to maize.

Nutritional Quality--CIMMYT's maize improvement program also includes work on the nutritional quality aspect of maize. We now have a range of high nutritional quality materials of different grain types that look and taste like normal materials and yet, as a result of the incorporation of the opaque-2 gene, they have substantially better protein quality than normal field maize. These quality protein maize materials are now yielding as well as the normal materials in several parts of the world.

International Breeding Program

We are involved in a multistage international breeding program which provides for a continuous and systematic flow of genetic material from the CIMMYT germplasm assembly line to farmers' fields. There are three main stages in this system:

(1) Development and improvement of broad-based gene pools for different specified areas of the world.

(2) Continuous improvement and refinement of maize populations with upgraded material from the corresponding gene pools.

(3) Selection of superior experimental varieties from the different populations.

Each of these improvement stages will be discussed briefly. Those who are interested in a more detailed description of this improvement system are referred to the publications cited below.*

Germplasm Development

Materials from the CIMMYT maize germplasm bank and new introductions sent to us by collaborators from many countries are systematically evaluated and added to the appropriate gene pools to extend and improve their genetic base. Thirty-one gene pools have now been assembled on the basis of climatic adaptation, maturity characters, and grain type. We have a range of materials to serve virtually every important production area and which meet local grain preferences in the developing world.

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* "Improving Adaptation and Yield Dependability in Maize in the Developing World," R.L. Paliwal and E.W. Sprague, CIMMYT, 1981; and CIMMYT Today No. 14, "Maize Research and Production in Guatemala," CIMMYT, 1981.

Each pool is grown at more than one site in Mexico each year where a multidisciplinary team identifies the superior plants at each location. Selection pressure, although sufficiently low to maintain genetic variation, does take into account yield potential, height and lodging tendency, maturity, disease and insect reaction, barrenness and synchronization of tasseling and silking, and uniformity characteristics. The best performing materials from these different gene pools are identified and transferred into corresponding populations which are at more advanced stages of improvement. These populations are, in turn, "fine-tuned" to meet specific production objectives.

Population Improvement

Farmers' conditions in the developing world require a range of improved maize materials to satisfy demand for specific adaptation, maturity and seed type. To serve this demand, CIMMYT is currently handling 27 different populations. These populations are improved using a multi trait breeding strategy, with variable relative weights given to different traits requiring improvement according to the problems encountered in areas where each population is meant to serve.

International Maize Testing Program

CIMMYT's international maize testing program has been designed: (1) to serve national programs that are at different stages of development, and (2) to combine into one mechanism a system for continuous improvement of maize germplasm as well as a germplasm delivery system to and from national programs. In some countries, the CIMMYT materials are used for almost direct selection of varieties for commercial release. In other programs, the CIMMYT material generally is introduced into national breeding schemes as new and superior germplasm sources.

National collaborators have contributed greatly to CIMMYT's international maize testing program. Each year, this dynamic improvement process continues to produce new experimental varieties from constantly improving maize populations. Today, most national programs in the developing world have released improved varieties which carry CIMMYT-distributed germplasm in their pedigrees.

International Progeny Testing Trials--CIMMYT begins to distribute advanced populations through the international testing system as soon as they are considered to be sufficiently advanced to be of utility to scientists in national programs. These advanced populations are first grown for three generations in Mexico and then in the fourth generation, or once every two years, each population is evaluated in international progeny testing trials (IPTTs) at six locations worldwide in three to six countries. Each year, half of the 27 advanced populations are used to form different IPTTs.

At this preliminary testing phase, the distribution of trials is limited to a relatively few testing sites which are representative of a range of areas in which the population is suited. The trials are monitored by CIMMYT scientists who work very closely with national collaborators. The latter play a very important role in CIMMYT breeding methodology. The quality of the data coming from the trials and the extent of progress in the improvement of the CIMMYT maize populations depend on that cooperation. Each trial consists of 250 full-sib families or progenies plus six check varieties (or hybrids) selected by the collaborator from locally available materials. Based on the across-site analysis from all locations where a particular IPTT is grown, 80-100 families are selected for the regeneration of the next cycle of the population. In addition, about 10 of the best families identified at each site by a national collaborator are used to form an experimental variety. This variety will carry the name of the site where the families were selected, and a number code to indicate the year of selection and the population from which it was derived. As an example, the experimental variety La Maquina 7822 was selected in 1978 from CIMMYT population 22, a tropical white dent population, at a testing location in La Maquina, Guatemala. Besides the site-specific experimental varieties, the 10 best families from each IPTT based on the across-site performance are used by CIMMYT to form an across-site variety, following the same nomenclature described above, e.g. Across 7822.

Theoretically, seven experimental varieties, six selected from site-specific data and one based on across-site data, can be produced for each of the 13 to 14 IPTTs tested each year. In practice, however, we do not receive data from all IPTT test sites, and therefore fewer experimental varieties emerge from each IPTT testing cycle. Nevertheless, in each improvement cycle CIMMYT develops some 60 to 70 experimental varieties.

Experimental Variety Trials--The relatively few superior experimental varieties selected from each IPTT cycle next are included in experimental variety trials (EVTs) that are tested the following year at several hundred locations in more than 80 countries. Since the best families identified in each population in the previous IPTTs are used to form these experimental varieties, it is expected that the varieties will show considerably higher performance as compared to the mean population yield. In addition to the yield, uniformity for maturity and plant and ear height are important considerations in forming experimental varieties.

Elite Experimental Variety Trials--The top 25-30 percent of the experimental varieties in each year's EVTs that show outstanding performance across several locations are selected for inclusion in elite experimental variety trials (ELVTs) prepared for distribution the following year. These ELVTs are also distributed on request to collaborators in more than 80 countries. Many of the elite experimental varieties are used in on-farm testing and simultaneous seed increase, stages which often precede commercial production.

Distribution of Maize Germplasm

CIMMYT does follow certain practices in the distribution of IPTTs, EVTs and ELVTs. The IPTTs have limited distribution to only six locations worldwide for each particular population. EVTs and ELVTs are much more widely available and are sent on request to any national maize or university maize research program in the developing world.

Depending on availability, private plant breeding institutions can receive bulk seed samples from the source pools and populations used to form the various IPTTs. They can also receive seed samples of selected experimental varieties as well as complete EVTs and ELVTs on an availability basis.

We think that this distribution of germplasm has been one of the very significant contributions of the maize program. We intend to continue this practice, which we know to have been a success.

Wheat Improvement Program

CIMMYT's wheat improvement program has expanded in scope over the last 15 years to include research on bread wheat, durum wheat, barley, and triticale. The program is organized into commodity-oriented sub-programs supported collectively by additional program units in pathology, new germplasm development, wide crosses, milling and baking, international testing, agronomy, and training. Regional programs serve as a linkage between resident research activities in Mexico and those of collaborating national programs as well as for certain area-specific research activities.

CIMMYT attempts to serve all small grain production areas, with the primary emphasis on the developing world. We endeavor to maintain the widest possible variation in our germplasm so that useful materials are available for all important production regions of the world. Our materials developed to date have consistently demonstrated, over a wide range of production conditions, their capacity to make maximum use of available nutrients and moisture for grain production. We would describe such materials as input efficient.

Yield Dependability

Among CIMMYT's general breeding objectives, enhancing the yield dependability of wheat, barley, and triticale receives a higher research priority than raising maximum genetic yield potential, *per se*. CIMMYT wheat and triticale germplasm has a relatively high level of resistance to most of the principal diseases, such as the cereal rusts. However, added resistance to certain diseases is still needed. These are primarily the minor diseases such as helminthosporium, septoria and scab. In barley, our program needs considerable amounts of added resistance.

Given the danger of disease epidemics when vast areas are planted to only one or two pure-line varieties, we are actively engaged in research and testing on such risk-reducing concepts as multiline varieties, varietal mixtures, broad-scale resistance, slow rusting or dilatory resistance, and geographic placement of varieties. These research avenues are complementary to our traditional approaches of identifying major gene resistances.

CIMMYT is also becoming increasingly involved in research to develop materials with additional drought, heat and cold tolerance, as well as greater tolerance to aluminium and other minor element soil toxicities. We are also engaged in research to develop disease-resistant wheat varieties which can be grown in the coolest season in subtropical areas, such as those found in eastern India, Bangladesh, Nepal and parts of East Africa. Several approaches are being followed. One is to screen the wide range of wheat, barley, and triticale germplasm for lines which exhibit genes for added tolerance to agro-climatic stresses. Such materials are then used as germplasm sources in our conventional crossing programs. In addition, we are increasing our efforts in wide crosses between wheat and barley, and between wheat and related wild species such as Agropyron and Elymus. We hope to find not only greater tolerance to subtropical conditions but also specific genes for resistance to the major diseases.

Yield Potential

Prior to the introduction of the genes for dwarfness into the CIMMYT materials during the 1950s and 1960s, the best wheat varieties rarely yielded above 4.5 t/ha. Even the best of the improved tall varieties faced a yield barrier because of their susceptibility to lodging when heavily fertilized. The semidwarf wheat varieties developed at CIMMYT were resistant to lodging and also carried genes for high grain efficiency, *per se*, raising maximum yield potential under optimum growing conditions to 8.5 to 9 t/ha.

Since the first release of these semidwarf varieties by national programs some 15 years ago, maximum yield potential has increased at a slower pace. While CIMMYT believes that further increases in maximum yield are possible, this objective is not given a major research priority since potential yields already far exceed average yields in most of the developing countries. However, through our research in crossing spring and winter habit wheat, barley, and triticale materials, and our work with germplasm possessing larger, more fertile heads, we see the potential for an additional 1 to 2 t/ha in varieties available during the 1980s. Further, we suspect that the yield potential in durum wheat and triticale may surpass the maximum yield potential of bread wheat. This is particularly true for triticale, which has already shown greater dry matter production than wheat. Further partitioning of the triticale dry matter toward grain rather than straw should push triticale yields higher than current wheat yields.

Our work in spring x winter crosses also indicates that the yield dependability of spring wheats can be increased through the introduction of genes from winter wheats. Spring wheats derived from the spring x winter crossing program are showing higher yield potential, better drought resistance, wider maturity ranges, and greater resistance to diseases such as septoria, stripe rust and some of the root diseases, than our pure spring wheat materials. On the winter wheat side, progenies resulting from the spring x winter crossing program show greater rust resistance, higher yield potential (mainly due to the semidwarf habit) and wider maturity ranges particularly for earliness, than the best pure winter wheats.

Wheat Program International Nurseries

In 1980, collaborating scientists in 101 countries requested about 1,900 trials of experimental wheat, barley, and triticale materials from 38 different nurseries. Each nursery consists of a set of lines--sometimes as many as 500 entries--which are constituted to serve the breeding requirements for particular production environments and disease problems. Five general international nursery categories are offered: crossing blocks, early generation F_2 material, screening nurseries (advanced lines), special disease and soil stress nurseries, and replicated yield trials. In addition, a number of regional nurseries--mainly used for disease screening and surveillance--have been operating in North Africa, the Middle East and parts of Asia, and South America.

The wheat program's international screening and yield nurseries are the most widely distributed. Screening nurseries include up to 500 of the most advanced lines from the CIMMYT program and are grown in double rows for observation and evaluation, unreplicated. Normally, the screening nurseries of the four major crops are distributed to some 150 locations around the world. Yield nurseries include 50 advanced lines and differ from the screening nurseries in that the materials are grown in replicated yield trials. National program collaborators are free to use any of the materials included in these nurseries. When material from an international nursery is released as a commercial variety, CIMMYT requests that the origin of the germplasm be recognized.

Germplasm Utilization by National Programs--The inclusion in the CIMMYT nurseries of advanced lines and varieties from all parts of the world has afforded CIMMYT and national cooperators the opportunity to observe the adaptation of materials to widely differing local conditions. The yield nurseries have been particularly valuable to those developing country institutions which lacked the resources for large-scale breeding programs. Some varieties included in these nurseries have been suitable for naming and commercial release without further improvement, permitting almost immediate seed multiplication for commercial production.

These same international nurseries also have offered national wheat scientists the opportunity for improvement through selection. Many of the experimental lines included in international nurseries which appear quite uniform under the local conditions where they were bred, have exhibited considerable variation when grown in other parts of the world. Thus, within the best lines of an international nursery grown at one location, national wheat scientists are able to select individual plants which are better adapted to local conditions,thus affording national programs the opportunity for crop improvement at minimal time and expense.

Finally, the international exchange of early generation segregating materials, like those contained in the CIMMYT crossing blocks and F_2 generation populations, has provided wheat scientists with a broad basis of genetic diversity--an essential ingredient in successful breeding programs. This wealth of germplasm has been used as crossing material in many national programs and has resulted in the release of hundreds of improved varieties around the world.

CIMMYT's Practices in Sharing Germplasm

In summary, CIMMYT shares its germplasm freely with other maize and wheat scientists around the world. Because of limitations regarding the total amount of seed available in relation to the many seed requests that come to CIMMYT, we do follow certain practices in deciding how to fill requests. First priority goes to scientists in developing country national programs and universities. Second priority is given to collaborators in developed country public sector programs. Third priority is assigned to private plant breeding companies. In practice, CIMMYT mainly shares with private companies the seed of early generation lines and of pools and populations on a bulk basis. Early generation materials are also shared with those national programs in the developing countries which tend to have relatively large and well-established breeding programs.

Because of the close partnership role played by national collaborators who participate in the international testing programs, CIMMYT does not engage in the naming of its advanced lines and experimental varieties. We believe this is most appropriately done by national programs for their respective countries. CIMMYT only asks national programs to recognize the source of the material when they release it as commercial varieties.

International Cooperation in Plant Breeding

CIMMYT scientists, particularly those such as Dr. Norman Borlaug who helped pioneer the concept of international testing, believe international nurseries initiated a new era in plant breeding. Before the advent of international nurseries in the early 1950s, many breeders were reluctant to release advanced lines from their breeding programs to fellow scientists for fear that new varieties would be named and released without the proper recognition of their efforts. Distribution of materials to other scientists was generally delayed until the variety had been named in the breeder's own country. Rarely were early generation materials (e.g., those still undergoing improvement and still expressing considerable genetic variation) distributed to other scientists.

International testing ushered in a new willingness to share early generation materials and advanced generation un-named lines. This, in turn, greatly increased the introduction of materials with genetic variability into national programs and helped break down a psychological barrier which had tended to isolate the efforts of individual plant breeders.

As an example, the CIMMYT-coordinated international maize and wheat improvement networks, based on a free and essentially unrestricted exchange of germplasm, have served as a unifying thread to bring together the work of thousands of scientists and hundreds of organizations worldwide. As a result of this collaboration, hundreds of high-yielding, input-efficient maize and wheat varieties with improved yield dependability have been released in both the developing and developed countries.

CIMMYT also benefits from international testing by being able to identify materials with broad adaptation and superior performance in terms of yield potential, disease and insect resistance, tolerance to stress, and grain quality. Such materials are used by CIMMYT in future improvement activities, thus reinforcing these useful traits in the subsequent breeding cycles of the germplasm. Simultaneously, national collaborators have had continuous access to a broad and constantly improving germplasm base.

Impact of CIMMYT-Distributed Germplasm on Maize and Wheat Production

Today, over 35 million hectares of wheat in the developing world and several million hectares in the developed countries are planted to hundreds of commercial varieties that carry CIMMYT germplasm in their pedigrees. Some of these broadly adapted lines, such as the CIMMYT cross 8156 which has been released as a commercial variety under different names (including Siete Cerros and Mexipak) in more than 25 countries and covered 15 million hectares at one time, have brought remarkable production increases throughout the developing world.

In maize, high-yielding broadly adapted varieties are beginning to reach commercial production in many developing countries. We have reports from more than 20 countries that over 75 varieties and hybrids with CIMMYT-distributed germplasm in their pedigrees have been released by national programs over the last five years. Such developments give us optimism that a similar pattern of expansion as in wheat in the area planted to improved maize varieties with consequent impacts on developing country maize production will occur during the 1980s.

Looking to the Future

On a global basis mankind depends on the land for 98 percent of its food supply. This is not expected to change significantly over the remainder of this century. In terms of human well-being, the most important food products are the cereals, the grain crops that occupy some 55 percent of the world's cropland area. Wheat, rice, maize, barley and the other cereal grains together supply well over half the food energy consumed directly by people and account for a sizable part of the remaining food energy consumed indirectly in the form of livestock products.

Depending on which projection one decides to use, world population will double over the 1975 count in 40, 60 or 80 years. This means that we will have to double world food production, within this time frame, just to keep even with the already often inadequate 1975 per capita food levels. We believe that improving yield levels on existing croplands will be the major source for the additional production needed to adequately feed the eight billion people who will be on the Earth by the 21st century.

It is an axiom of experience in plant breeding that if you stop, you regress. The natural enemies of our crops are themselves evolutionary and active. Rusts and other pathogens mutate, insects develop resistance to chemical and genetic controls, and environmental policies can affect the components of agronomic practices. Consequently, the CIMMYT staff is deeply concerned that the crop improvement gains already made be vigilantly guarded. These considerations enhance the importance of the maintenance of CIMMYT's services such as the international testing networks, our germplasm banks, and our work in germplasm improvement.

CIMMYT, in planning program priorities for the future, must continue to ensure that its programs help to increase global food supplies as well as domestic production in food-deficient areas, particularly in the low-income countries. The nature of these demands differs from country to country. Some governments will focus on increasing production while others will specify production increases among certain classes of farmers and/or crops. Since the national research and production programs of the developing countries vary notably in their research capacities, CIMMYT must be sensitive to these differences if they are to serve national programs effectively. We must retain sufficient flexibility to respond to the needs of collaborating national programs.

Increases in developing country food production will not come easily even with carefully focused research. There is no technological panacea for solving the food problems of the developing world in the years ahead. The 120 million hectares of maize and wheat land in the developing world that have yet to receive the benefits of improved varieties, in combination with other appropriate inputs and public policies, can play a major role in raising future production levels.

Despite the difficulties facing developing countries, the CIMMYT staff is convinced that, from a biological viewpoint, it is possible to expand agricultural food production over the next 20 years at a rate that will equal or slightly exceed the rate of aggregate population growth. Achieving this increase and distributing it more equitably, however, will require political stability, the determination of national governments to increase investments in their agricultural sector--including research and extension--and the continued sharing of new knowledge and genetic material among the community of nations.

Table 1: Brief description of the CGIAR-supported centers

CENTERS	DATE FOUNDED	PROGRAM EMPHASIS
Commodity-Oriented		
IRRI International Rice Research Institute	1960	research on rice and rice-based farming systems
CIMMYT International Maize and Wheat Improvement Center	1966	research on maize, wheat, barley and triticale
CIAT International Center of Tropical Agriculture	1967	research on cassava, field beans, rice and tropical pastures, primarily in Latin America and Caribbean
IITA International Institute of Tropical Agriculture	1968	research on farming systems for humid tropics including roots, tubers, food legumes, maize and rice
CIP International Potato Center	1971	research on potatoes
ICRISAT International Crops Research Institute for the Semi-Arid Tropics	1972	research on sorghum-millets, food legumes and farming systems for the semi-arid tropics
ICARDA International Center for Agricultural Research in Dry Areas	1976	research on durum wheat, barley, lentils, broad beans and farming systems for drier regions with a Mediterranean climate
WARDA West Africa Rice Development Association	1971	research on rice in West Africa
IBPGR International Board for Plant Genetic Resources	1974	collection, documentation and conservation of genetic resources of important crop species
Livestock-oriented		
ILCA International Livestock Center for Africa	1973	research on African livestock production systems
ILRAD International Laboratory for Research on Animal Diseases	1973	research on diseases of African livestock
Management and Policy-oriented		
IFPRI International Food Policy Research Institute	1975	policy research on world food problems
ISNAR International Service for National Agricultural Research	1980	technical assistance to developing countries to plan, organize and manage national agricultural research systems

FIGURE 1. CGIAR MEMBERSHIP AND SUPPORTED CENTERS

CGIAR Membership as of October 1979

Continuing Members

Countries

Australia	Ireland	Saudi Arabia
Belgium	Italy	Sweden
Canada	Japan	Switzerland
Denmark	Netherlands	United Kingdom
France	New Zealand	United States
Germany	Nigeria	
Iran	Norway	

International Organizations

African Development Bank
Arab Fund for Economic and Social Development
Asian Development Bank
Commission of the European Communities
Food and Agriculture Organization of the United Nations
Inter-American Development Bank
International Bank for Reconstruction and Development
International Fund for Agricultural Development
OPEC Special Fund
United Nations Development Programme
United Nations Environment Programme

Foundations

Ford Foundation
International Development Research Centre
Kellog Foundation
Leverhulme Trust
Rockefeller Foundation

Fixed-Term Members Representing Developing Countries

Asian region	India Philippines
African region	Kenya Senegal
Latin American region	Costa Rica Peru
Southern and Eastern European region	Greece Romania
Near Eastern region	Egypt Syria

The CGIAR–Supported Centers

CIAT: Centro Internacional de Agricultura Tropical. Cali, Colombia
CIMMYT: Centro Internacional de Mejoramiento de Maíz y Trigo. Mexico, D.F., Mexico
CIP: Centro Internacional de la Papa. Lima, Peru
IBPGR: International Board for Plant Genetic Resources. Rome, Italy
ICARDA: International Center for Agricultural Research in the Dry Areas. Beirut, Lebanon
ICRISAT: International Crops Research Institute for the Semi-Arid Tropics. Hyderabad, India
IFPRI: International Food Policy Research Institute. Washington, D.C., United States
IITA: International Institute of Tropical Agriculture. Ibadan, Nigeria
ILCA: International Livestock Center for Africa. Addis Ababa, Ethiopia
ILRAD: International Laboratory for Research on Animal Diseases. Nairobi, Kenya
IRRI: International Rice Research Institute. Los Baños, Philippines
ISNAR: International Service for National Agricultural Research. The Hague, Netherlands
WARDA: West Africa Rice Development Association. Monrovia, Liberia

THE SIGNIFICANCE OF PLANT BREEDING BY THE PRIVATE SECTOR

C. Mastenbroek*

Summary

1. The pre-Mendelian period

No doubt selection was being carried out by unidentified individuals when wild plants were first domesticated. Later, a limited number of identified breeders practised actual selection work in cereals, vegetables, flower plants and fruit trees, in order to obtain better varieties for cultivation. Their work was empirical in nature, based on personal interest in and knowledge of the crop, on enthusiasm for and dedication to this kind of spiritual activity, on intuition and experience. Their work consisted in pedigree selection in local and regional varieties or land races.

The first recorded cross was made in 1719 by Thomas Fairchild between Dianthus caryophyllus and D. barbatus, giving birth to Fairchild's Sweet-William. The first cross in peas was made in 1800. John Goss was, in 1822, the first to select within a cross progeny of peas for better varieties to cultivate. In France, Sageret crossed and selected Cucurbitaceae from 1826 onwards. Sheriff, from Scotland, was the first recorded breeder to make wheat crosses, followed by selection.

Towards the end of the 19th century a good number of practical breeders were active, e.g. in Germany in sugar beet, cereals and particularly in winter rye; in France in wheat and vegetables; in the USA in maize and potatoes; in the Netherlands in potatoes, winter rape (seed), peas and tulips; in Sweden in cereals; in the United Kingdom in potatoes and vegetables. Special mention should be made of Luther Burbank in the USA, who started around 1880 with potatoes and who became famous for his outstanding new varieties of plums and raspberries. He already selected for better suitability for transportation and he performed species crosses extensively.

2. The period after 1900

The general applicability of Mendel's laws, the formulation of the pure-line concept by Johannsen and much other research in genetics and plant breeding methodology, had an ever increasing influence on practical plant breeding. The same is true for developments in population size, in consumption habits, in food preservation, in transport facilities, in crop husbandry, in mechanization of harvesting, storage and grading and in greenhouse technology and management. Depending on the crop, selection procedures became more complex, more sophisticated, and soon moved from simple selection in impure land varieties to selection in populations resulting from man-made crosses. Backcrossing was widely practised, in particular with the aim of introducing disease resistance from obsolete or foreign varieties or even from different species and genera. Hybrid varieties of maize for grain and silage took the market. The detection of male sterility and its genetic mechanisms greatly stimulated the breeding of hybrid varieties in maize, onions, sugar beet, tomato and several other vegetables and flower plants. Self-incompatibility became widely adopted in the production of hybrid varieties of Brussels sprouts. Greater emphasis was placed on the suitability of the harvested product for its ultimate use. Whenever possible, selection in this respect is performed in the early stages of breeding and in laboratories of the breeders themselves.

Private plant breeding has by necessity become more professional for most crops. Some breeders and breeding organizations specialize in one crop or a few crops only; many others are dealing with many crops for reasons of diversification. Thanks to plant variety protection legislation, returns from private plant breeding have improved in recent decennia in spite of an enormous increase in costs. However, compared to the present level of bank interest, the profitability of breeding enterprises is low. This has led to close cooperation, joint ventures, concentration, and the taking over of some firms and family enterprises by larger organizations.

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The achievements of plant breeders in the private sector are undeniable. In many existing mandatory and recommending national lists of varieties the majority of the cultivars are private in origin. Privately bred cultivars of cereals, potatoes, sugar beet, grasses, cabbages and other vegetables have been or are being grown on an international scale and have contributed considerably to a striking increase in yields and food production, desperately needed in our present-day world.

3. The future

The potentialities of well-established breeding techniques are certainly not exhausted; cultivars to come are very likely to yield even more. Nevertheless, research in new techniques of somatic hybridization, gene introgression and selection at the single cell level has started and is well under way already. Some predict results of real novelty and great value; others are more sceptical. Private enterprises are contributing to this research, but medium and small ones will only be able to use the first results for further improvements.

Because of the range of cultivars needed, not only on a world-wide scale, but also regionally, to cater for the variety of growing conditions, and to minimize the risks of diseases developing to a damaging level, a variety of methods and initiatives should continue to be exercised. There will be ample room for private plant breeding to play its role in the production of more food for a growing world population.

1. The pre-Mendelian period

It is a well-known matter of experience in aid to developing countries that undeveloped human beings can be quite smart and clever, thus demonstrating their intellect. There is every reason to believe that primitive people, in their wanderings, took the biggest and best looking ears, fruits, berries, seeds and tubers while collecting their daily food in nature. It may be assumed that in those times yield per hour of collecting, rather than yield per area, was the leading principle for choosing the biggest ears, etc. There is even more reason to believe that, when they began to settle and to actually grow crops for their needs, they did in fact choose and select, thus initiating domestication of plants that grew wild until then, some 10,000 years ago. Regarding cereals, it is likely that at that time ears that retained the seed were preferred to ears that shed their progeny. It may be assumed that mass selection was directed towards this useful character. It is apparent from the poetry of Virgil that the Romans were already aware that their cereal crops were not uniform. It was recommended to harvest with special care if the yield, or part of it, was intended to be used as seed for the next crop. It was even advised to pick the best ears in order to maintain the identity of the various types under cultivation, as well as to prevent admixtures of lower value from being multiplied into the next crop.

In literature nothing is recorded about what our ancestors of the middle-ages did in this respect. The first or oldest record is about Le Couteur of Jersey, around the year 1800. A guest of his, Professor La Gasca of Spain, pointed out to him that his wheat crop looked far from uniform. Le Couteur then in one field picked out 23 individual ears of different, but appealing shape and size and planted the ear progenies in separate beds. He observed differences in various properties, for example in grain yield. He decided to maintain a few of the best and to discard the others, apparently assuming that the good properties would be carried on. This proved to be the case, since some of Le Couteur's selections became widely grown in Great Britain and Northern France. One, by the name of Bellevue de Talavera, was still cultivated around 1910, about a century after it was isolated.

About 20 years later, in 1819, Patrick Sheriff, a country gentleman of Haddingtonshire, Scotland, began selecting extraordinarily good-looking single ears from wheat and panicles from oat crops on his farm. By 1857 he had more than 70 individual wheat selections in trials, in which he compared the progeny of the selected wheat ears with the popular varieties of that time.

In 1860 his comparative wheat trials covered 12 acres (some five hectares). Eventually only four of the tested selections reached the commercial stage. That made him decide to abandon the idea of picking out only those ears and panicles that were extraordinarily good-looking. From then on he took only ears and panicles that were merely good-looking. From this period three wheat and four oat varieties came forth.

Also around 1820 the Chevalier variety of spring barley was found, one might say, by mere chance. A field worker, who had been threshing barley during the day, found part of a beautiful ear in one of his shoes, after having returned home for the night. He planted the grains in his garden next Spring and handed their progeny over, not to his employer, but to his landlord, the vicar Dr. Charles Chevalier. It is not known in detail how he handled the material, but one thing is certain: the famous Chevalier barley emerged from it.

In subsequent years, many more outstanding varieties were selected from land races or local varieties that were, genetically speaking, mixtures of various genotypes. In several countries this kind of breeding work was executed in the self-pollinating cereals by a gradually increasing number of breeders, until around 1900. This kind of work, done in particular at Svalöv, Sweden, became reputed.

Hallett (about 1860) was an English breeder who expected good results from continued selection of the best grain from the best ears of the best progeny. He treated his plants like pets, gave them lots of room in widely spaced stands, applied heavy dressings of organic fertilizer and obtained a very high rate of multiplication. But when he made comparisons in a kind of test that came close to farm practice, he was very much disappointed by the evident lack of progress over the first cycle of selection. His Lamarckian method of continued pedigree selection proved to be no better than the method of one single selection cycle, as employed by Le Couteur and Sheriff. In Svalöv the same conclusion was drawn from their efforts to improve the stiffness of the straw of the Chevalier spring barley by repeated and continued pedigree selection within the variety.

With our knowledge of and experience with the pure-line method since Johannsen, we can easily explain why Hallett was unsuccessful. The method appeared to be successful, however, when applied to rye, a cross-pollinating crop. In Germany, von Rimpau started in 1867 with what we would now call "positive mass selection"; he achieved good progress, but more was attained by later rye breeders, who applied family selection and continued pedigree selection, eventually combined with the Rest-Saat Methode (Laube). The German rye varieties proved to be widely adapted and were cultivated in many countries over a long period. Whether they were completely stable over this long period is a question of academic rather than of practical importance. I think it is very unlikely that they were stable and that has been good for them. Now, with plant variety protection, breeders have to pay a bit more attention to this aspect.

Sheriff wrote in his book, published in 1873:

"New varieties of the cereals can annually be obtained from three sources--from crossing, from natural sports and from foreign countries."

He described how to perform crossing in wheat. It appears that nowadays it is still done in exactly the same way as he did it over a century ago.

Another quotation from his book goes as follows:

"Always cross with the seedlings which inherit in the greatest degree the properties you wish a cereal to possess."

These words show that by 1870 Sheriff had turned to crossing wheat varieties, followed by selection of individual plants from the progeny. He, however, believed that Thomas Andrew Knight, also a country gentleman, was "the first individual in Britain known to have crossed wheat."

True as this may be, he certainly was not the first recorded person, who wittingly carried out a cross in the plant kingdom. This was Thomas Fairchild. He performed, in 1719, the species cross carnation Dianthus caryophyllus x sweet-william Dianthus barbatus and obtained a sterile F_1 hybrid, which was subsequently multiplied vegetatively and became known by the name "Fairchild's Sweet-William".

The oldest recorded artificial cross in peas, performed by John Goss of Devonshire, England, between a blue and a white seeded variety, dates back to 1820. He observed the phenomenon of segregation in the F_2, but did not count numbers and did not grow separately the progenies of the F_2 individuals, as Mendel did about 40 years later. But John Goss was, as far as is known, the first to cross pea varieties with the aim of selecting within the progeny new types,new varieties with a better value for the grower. That was some 150 years ago. At about the same time William Herbert tried to improve winterhardiness in some flower plants by way of crossing. He found that the F_1 hybrid was intermediate between the parents in this respect.

In France, the practical agronomist Sageret reported in 1826 about crosses he had made in the Cucurbitaceae. He is considered to be the first one who clearly recognized which characters come together as dominant and recessive.

In Germany, in the period 1830 to 1835, the physician Carl Friedrich von Gärtner carried out almost 10,000 separate crosses in 700 different species belonging to 80 different genera, mainly of flower plants, but also oats and, again, peas. There is no record of selection being made.

The first wittingly performed cross-pollination in potatoes is attributed to the market gardener Wery of Liège, Belgium, in 1842. In the same period Goodrich in the USA was selecting potato seedlings for better properties. It is not known when he made his first cross, but he certainly was very successful. His variety Garnet Chili, obtained in 1853 from a selfed progeny of Rough Purple Chili, had many commercially successful varieties among its derivatives. Before the end of the 19th century, Paterson in England, Richter in Germany and Veenhuizen in the Netherlands were active as potato breeders. Another breeder who started off with potatoes was the well-known Luther Burbank in the USA. It must have been around 1880 that he selected a new potato. He sold it to an interested merchant for the lump sum of $ 125; the price included two generations of tubers and all proprietary rights. The variety became known as the Burbank potato, and eventually proved to be of very great value for the USA. It is possible that it is still grown, as indeed is Russet Burbank, a mutant with a rough skin.

Burbank acquired more fame with his new varieties of plums, raspberries, blackberries and several other species. He carried out several thousands of crosses between varieties and between species and genera. Some yielded stable hybrids (allotetraploids probably); other crosses segregated into an enormous variation from which he was able to bring forward outstanding new varieties. He wittingly selected plums with a better tolerance to being transported. He also selected grasses for lawn purposes.

Burbank furthermore collected and maintained accessions from various parts of the world; he even employed two plant-collectors. In 1904 he grew 2500 different species, 500 of which had been imported from South America and Australia. After having successfully produced species-hybrids, he soon found that repeated backcrossing was necessary in order to arrive at a sufficient level of production and quality. He detected that some characters of the young plant were correlated with important properties of the mature plant and its fruits. By making use of such "guiding characters" he was able to work through over 300,000 plum seedlings in a period of only 20 years.

Burbank also found one individual without spines among thousands of seedlings of the Opuntia cactus. In his enthusiasm he believed that this cactus would become a crop for the desert, which would enable the earth to feed twice the population of his day. Well, the world's population has since more than doubled, without his dream of cactus cultivation coming true.

There can be no doubt that Burbank was a very talented breeder. Whether he was a good businessman is another point. As mentioned earlier, he sold his Burbank potato for only $ 125. Later, he invariably sold promising selections and the transactions always included all proprietary rights. He did not want to bother about maintenance breeding, but, as a breeder, Luther Burbank was far ahead of his time.

Since 1675 there have been issued, mainly by university professors, several publications about sex in plants, that helped people to gradually understand how seed formation takes place. Reports on crossing experiments, carried out at universities were published from about 1750 onwards (e.g. Camerer, Linnaeus, Koelreuter, Wiegmann, Godron, Naudin, Spillman, to mention a few). There is, according to the literature I looked into, little indication that practical plant breeders were influenced by these publications, until 1900. If this really is so, those breeders of the early days--including those who have not been mentioned--deserve our sincere respect even more.

2. The period after 1900

After the rediscovery of the laws of Mendel, the sciences of genetics and plant breeding developed at an accelerating speed. The results of research became readily available to breeders.

By the turn of the century, exploiting the artificial variability resulting from man-made crosses in self-pollinating and vegetatively propagated crops had started, but was not yet common practice. Within a few decades, however, the method of crossing varieties was generally accepted as yielding more and more valuable variability than occurred in local varieties. It was the general feeling that these were fully used up in respect of valuable properties. Nowadays, however, we have come to realize that they might still have value for future plant breeding. It is, therefore, highly desirable to store them in gene banks, before they all disappear.

Grass breeders have continued until the present day to draw from natural sources, both in temperate and in tropical zones. Their big problems are where to collect, how to test large numbers of individual plants and estimate their tolerance to be trodden on and played upon, how many genotypes to combine in one variety and how to test for suitability in species and variety mixtures. Without having been able to answer all these difficult questions, they have certainly come forth with many excellent varieties, beyond any doubt. Meanwhile, they too have started to make crosses between varieties, expecting to create progenies with a higher frequency of valuable individual genotypes than was present in the natural accessions.

In cereals, the technique quickly evolved into crossing between more than two varieties in order to create a still wider gene pool. The repeated backcross with one recurrent parent became popular for the introduction of a specific character into the recurrent variety. Some breeders realized that in doing so one could hardly expect transgression to occur, so they practised the use of various adapted varieties in the backcross program. The backcross method was and still is widely used in breeding for disease resistance. Here, difficulties were encountered because of the mutability of the pathogenic organisms. Notorious in this respect are the rust and mildew diseases of cereals and some vegetables and of (late) blight in potatoes. Combinations of different genes for resistance to different races have been achieved, but success proved to be temporary in a number of cases. Fortunately, however, sources of resistance are still not yet completely exhausted.

Some breeders believe in multiline varieties which incorporate a number of resistance genes, the components being otherwise so alike that the mixture can be handled in farm practice as a single variety. Such a mixture is likely to put a brake on the development of the disease in the field.

Other breeders, however, reason that, because this method calls for repeated backcrossing using one recurrent parent, yield potential will not increase. They think that the breeding of single-genotype varieties should continue, using different genes for resistance, and that new varieties, possessing different resistance genes as well as the highest available yielding potential, should be grown together as a mixture. Of course, agronomically speaking, the varieties in the mixture must be similar enough to be handled as a single-genotype variety. Maybe this is not easy to realize.

Still other breeders think it better to concentrate on so-called field resistance, which type of resistance protects the plant from being attacked to a damaging level and which is completely or at least largely unaffected by pathogenic differentiation. These breeders believe in the possibility of combining top yield with field resistance. They point out that this combination is by no means rare in the field of interaction between plant and pathogen.

Hybrid vigour was already observed to occur in F_1 hybrids by Koelreuter and von Gärtner about 150 years ago. Maybe Koelreuter overestimated heterosis when he wrote "to expect that hybrids of trees could produce the same quantity of wood in half the time of the parent species." The phenomenon has become widely and very successfully exploited in breeding hybrid grain and silage maize varieties. The results of maize breeding have been very striking, not only in respect of raising the yield level, but also in respect of adaptation to marginal growing conditions.

More recently, hybrid vigour has been shown to be of great value in Brussels sprouts. Whereas in maize the separation of the sexes proved to be very useful in the technique of producing hybrids, in Brussels sprouts self-incompatibility is used to produce hybrid seed on the basis of inbred lines. The inbred lines can be maintained by selfing when the flowers are pollinated in the bud stage.

In onions, maize, lucerne, sugar beet, fodder beet, tomatoes and several other vegetables as well as in flower plants, good use has been and is being made of male sterility in the production of hybrid varieties, in beets in combination with polyploidy. The techniques are complicated, but the results are worth it.

In wheat, male sterility appeared in some species crosses. It was shown to be possible to maintain sterility as well as to restore fertility by means of specific genes. A complicated and sophisticated breeding system was designed, but great difficulties were encountered in transforming the self-pollinating and to some extent closed-flowering wheat plant into a pollen-shedding open-flowering version. In fact, the breeding of hybrid wheat varieties on a realistic commercial scale has not been successful so far. In recent years research has been carried out into the possible use of chemically induced male sterility.

Cross pollination is not expected to be a problem in the production of hybrid varieties of rye, with which a few breeders are occupying themselves.

The aim of plant breeding is to create better varieties, better for cultivation and better for use. With changes in farm and nursery management and crop husbandry, diminishing availability of manual labor, increased mechanization and in recent years energy prices going up at an enormous speed, the wishes of the growers as to the properties of the cultivars have changed and developed continuously and will go on doing so in the future. It is the task of the breeders to satisfy these changing demands as quickly as possible. It is an even bigger challenge to anticipate the changes to be expected and to have the answers ready when needed. Such activities, of course, are financially speaking very risky, because it is difficult to foresee what is coming.

The economy of growing farm and nursery crops calls, as always, for a high yield. And since we have come to care about our brothers and sisters in developing countries, where the need to produce food is often not a matter of luxury but a sheer necessity to stay alive, the demand for more yield per hectare has grown in emphasis. This is, in the first place, of importance for crops that directly produce the staple human foods. It is also valid, in order to improve the diet in its quality, for crops that produce food for dairy and beef cattle, and for vegetables and fruits.

With an increasing standard of living, consumption habits change. This calls for specialized varieties, optimally suitable for canning, deepfreezing, or being transported over long distances. There is also a demand for varieties adapted to different day and night rhythms, to a lower level of light intensity and, most recently, to yielding well with less artificial heating.

I realise that this picture is far from complete, but it will suffice to demonstrate the ongoing requirements for new cultivars. In trying to meet these requirements with the largest possible chance of success, breeders have no option other than to select for these specific properties in their fields, greenhouses and laboratories. For this, they need specialized staff provided with specialized equipment. Because of the infrequent occurrence of the desired property, they will usually have to test a large number of selections, and therefore they must perform these tests as early as possible in the breeding cycle and on samples which are as small as possible. This requires specialized methods of assessment.

It will be evident that all this adds up to a substantial increase in the cost of breeding work. Capital investment has gone up a great deal; consequently financial risks have also grown considerably. At the same time competition has increased. Growers have become more aware of the good sense of growing new and better varieties, which has shortened the commercial lifetime of the individual variety. This has increased the financial vulnerability of breeders, in particular of those who specialize in one or in just a few crops. These developments tend to work in favor of the bigger breeding enterprises that deal with many crop species.

Other possibilities to reduce the risks have also been seized, namely close cooperation, joint ventures, amalgamation. But still, commercially successful varieties are necessary for survival. Some breeders and breeding firms, having failed to produce such varieties, have ceased to exist; others have been taken over by bigger enterprises. The high bank interest rates of recent years have made the existence of the smaller breeder and the family enterprise more difficult than it used to be. On the other hand, there remain breeders who are able to pay the high costs, to make the necessary investments in machinery, buildings and equipment, and who have the good fortune of producing commercially successful varieties. They benefit from plant variety protection, but at the same time it is evident that they depend for the continuation of their work on royalty income or on the built-in protection provided by the nature of hybrid cultivars.

Some 60 years ago the idea of plant breeders' rights was raised. The idea gradually attracted more attention from the breeders, and resulted eventually in the foundation of ASSINSEL in 1938. During his Presidency of ASSINSEL, which lasted for about 30 years, Ernest Tourneur of France in particular was very active in promoting the idea of plant breeders' rights, or plant variety protection.

When we look at the existing mandatory and recommending lists of varieties, it appears that private plant breeders have indeed been successful. Let me give a few examples of numbers of varieties of private and public origin for a number of crops and countries.

Table 1: Number of listed varieties of private and public breeders respectively (1981)

	England		France		Germany (Fed. Rep. of)		Netherlands	
Winter wheat	7	9	73	8	46	2	13	2
Spring Wheat	3	1	20	1	21	-	10	-
Winter barley	5	2	23	4	28	2	3	2
Spring barley	18	3	55	4	41	-	13	1
Winter rye	4	-	6	1	8	2	5	-
Spring oats	3	4	19	7	25	-	8	-
Maize	10	1	200*	41	42	4	11	1
Dry peas			15	3	4	-	10	-
Fibre flax			12	1			6	-
Grasses	59	23	158	98	391	7	133	12
Potatoes	10	10	101	6	125	1	97	1
Sugarbeets	10	-	90	-	29	-	8	-
Winter rapeseed			8	2	13	-	2	-

* Including 53 of USA origin

Table 2: Number of varieties of the major field-grown vegetables and strawberries of private and public breeders respectively, listed in the Netherlands (1981)

Gherkins	7	1	Spinach	33	-
Cauliflower	18	-	Brussels sprouts	22	-
French beans	26	-	Garden beans	19	-
Peas	26	-	Strawberries	3	12
Lettuce	10	-			

Having looked at these figures it should be realized, of course, that the picture might be different for the percentage of the crop area covered by each of the two groups of varieties. Relevant figures are not readily available, however.

Table 3: Percentage of crop area covered by varieties of private and public breeders respectively (1981)

	England		France		Germany (Fed. Rep. of)		Netherlands	
Winter wheat	40	60	97	3	95	5	95	5
Spring wheat	82	18	100	-	100	-	100	-
Winter barley	80	20	81	19	94	6	88	12
Spring barley	90	10	94	6	100	-	73	27
Winter rye	100	-	92	8	99	1	100	-
Spring oats	82	18	89	11	100	-	100	-
Maize							99	1
Peas							100	-
Flax							100	-
Potatoes							100	-
Sugarbeets							100	-
Winter rapeseed							100	-

Table 4: Percentage of spring and winter barley area covered by varieties of private and public breeders respectively

	Austria		Belgium		Denmark		England		Federal Republic of Germany	
Winter barley	100	-	80	20	100	-	80	20	94	6
Spring barley	100	-	100	-	98	2	90	10	100	-

	France		Netherlands		Spain		Sweden		Switzerland	
Winter barley	81	19	88	12	100	-	100	-	100	-
Spring barley	94	6	73	27	100	-	-	-	not known	

The figures just presented are very incomplete. I would have liked to include the United States of America, Canada, Japan, Australia and New Zealand, but I have not been able to gather sufficient data. I have reason to suppose that the situation in the United States of America, for example, is different from that in the European countries in respect of the small cereals, potatoes, grasses, and sugar beet, but that for maize and vegetables the situation might not be so very different.

Incomplete as the figures are, they nevertheless clearly demonstrate that where private plant breeders are active they have been able to furnish a wide range of varieties. Of course it must be borne in mind that the aims of public plant breeding vary from country to country. In Great Britain, for instance, government institutes breed and market varieties, whereas in the Federal Republic of Germany, the Netherlands, Sweden and Denmark, the governments restrict themselves almost completely to research; they support the private sector with information and material, but do not enter into commercial competition. This clearly strengthens the position of the private breeders and greatly diminishes the number of varieties of public origin on the market. In some other countries, for example in France, there exists the possibility of close cooperation, in some form or another, between private plant breeders and government institutes, and in other countries, for example the United States of America, public institutes create new varieties but leave multiplication and marketing to the trade.

The policy of international breeding centers like CIMMYT has been to make their varieties or material freely accessible to the growers and to the trade without claiming any proprietary rights.

Both the national and international market position of some individual varieties is quite conspicuous. There have been such varieties in the past and there are at present, in particular of potatoes, sugar beet, barley, wheat, winter rye, winter rapeseed, maize, cabbage, roses, vegetable peas. The majority of those varieties are of private origin.

3. The future

The scope of techniques and methods employed at present will not be exhausted in the near future. The necessity to increase the yield potential, to create new varieties adapted to new environments and to new husbandry, and capable of meeting new demands, will probably bring about a further shift to more complicated techniques and sophisticated equipment. Research will be more important than ever before. Many breeders will have to rely on scientific research by government institutes; only the bigger breeding enterprises will be able to participate in this research.

This situation presents itself already in the areas of somatic hybridization, gene transplantation, and selection at the single cell level, all of which are new techniques that seem to open up possibilities of creating new man-made hybrid crops, of supplying crop plants with properties from unrelated species and of handling not thousands of individual plants, but hundreds of thousands of individual cells in selecting for certain properties. Some scientists are very optimistic and predict results of real novelty and great economic value; others are more cautious, even sceptical, and draw attention to the difficulties encountered in bringing triticale to a useful level. They argue that hybrids between wheat and rye have long been known to occur as a result of spontaneous crosses, albeit that the hybrid was sterile. A lot of scientific research and practical selection work has been devoted to the improvement of triticale over a long period of time. Taking this as an example, the practical possibilities of transferring properties from one species or genus to another should not be overestimated. Difficulties will be manifold, disappointments probably numerous, and costs will certainly be high. Nevertheless, it seems worthwhile to continue the investigations because the world's population is still growing, and still more food will be needed. Production per hectare will have to go up, and for this to happen, a large number of cultivars will be necessary to give the (new) species a wide scale of adaptation in view of the extensive differences in growing conditions. It is at this point that breeders can step in and make additional variations on the new theme provided by basic research. Many breeders will have to participate in order to reach the best possible practical economic effect of that research. There will therefore be ample room for private plant breeders who, notwithstanding a still wider scientific background, will continue to need experience, intuition, dedication and enthusiasm for their work, which they love for its creative character.

THE RICE IMPROVEMENT PROGRAM OF THE INTERNATIONAL RICE RESEARCH INSTITUTE (IRRI)

G.S. Khush*

Summary

The rice improvement program of IRRI is an interdisciplinary program involving scientists belonging to various disciplines such as plant breeding, plant physiology, plant pathology, entomology, agronomy, cereal chemistry and soil science. It has five major components as follows:

1. Germ plasm collection, conservation and characterization

We now have more than 60,000 cultivated varieties of rice besides several hundred accessions of *Oryza glaberrima*, the African cultivated rice, wild species of *Oryza* and genetic testers of *Oryza sativa*. Seeds of these collections are being conserved for medium-term and long-term storage. Cultivated varieties are being characterized for morpho-agronomic traits and for tolerance to various biological and physico-chemical stresses.

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2. Development of improved germ plasm

We make about 5,000 crosses every year, grow about 120,000 pedigree nursery rows and yield test about 600 entries in replicated yield trials. To date eleven improved varieties have been released by IRRI and twelve IR varieties by the Government of the Philippines. Other national rice improvement programs in Asia, Africa and Latin America have released 73 IRRI bred lines as varieties. Thus 96 varieties have been released from IRRI bred materials which are planted on over 30 million ha. of rice land.

3. Disciplinary research

Disciplinary research emphasizes the development of screening techniques and identification of donors for various biological and physico-chemical stresses. Research on breeding methods and on genetics of resistance, biochemical basis of resistance and variation in the disease organisms and insect pests is emphasized.

4. Training of rice scientists

A formal four-month training course in the techniques of rice improvement is conducted twice a year. Each session accommodates about 30 trainees. To date 282 trainees from rice growing countries have participated in the formal training program. Up to 15 rice scientists work towards MSc or PhD degree programs each year under a collaborative arrangement between IRRI and the University of the Philippines.

5. International collaboration

More than 80,000 seed packets of improved varieties, breeding lines and entries from the germ plasm bank are sent to rice scientists of the world every year. Seeds are supplied either on the basis of requests from individual scientists or are sent as part of international nurseries.

The International Rice Research Institute is one of the thirteen centers supported by the Consultative Group on International Agricultural Research (CGIAR), one of the nine such centers working on crops and one of the two centers which are mono-commodity centers. The research program is organized into ten different areas and one of the biggest is the rice improvement program or the Genetic Evaluation and Utilization (GEU) Program, which I am going to talk about this afternoon.

Before I begin I would like to present two slides showing where rice is grown. Ninety-two percent of the world's rice is grown in Asia and only 8% elsewhere. India and China grow about 50% of the total rice produced in the world. The total area under rice in the world is about 150 million hectares. Total world production of rice is about 400 million tons. The yield is lowest in the less developed tropical regions, where most of the rice is grown, and the average yield there is 2 to 2.5 t./ha. as compared with an average yield of 6 t./ha. in developed parts of the world such as Japan, Europe, United States of America and Australia. Rice is grown under various ecological conditions ranging from upland hill slopes to deep water conditions where the water might be as much as 6 meters in depth, for which varieties of floating rice are required. Fifty percent of the rice is grown in situations where there is good water control, mainly as a result of irrigation.

The GEU program, or the rice improvement program of IRRI, has five major components: germ plasm collection and conservation, development of improved germ plasm, disciplinary research, training, and international collaboration.

1. Germ plasm collection and conservation

The collection and conservation program involves the two cultivated species, namely *Oryza sativa* and *O. glaberrima*, the wild species, genetic testers and mutants. We have 60,000 varieties of *O. sativa* in our collection, about 2,000 of *O. glaberrima*, several accessions of wild species, and about

500 genetic testers and mutants. More than 70,000 samples of the different species and cultivated varieties of rice are stored in a germ plasm bank at three different temperatures, for short-term, medium-term and long-term storage.

2. Development of improved germ plasm

The germ plasm improvement program is the largest component of the rice improvement program. Improvement is sought in the following problem areas: agronomic characteristics, grain quality, disease resistance, insect resistance, adverse soil tolerance, drought tolerance, and deep water and flood tolerance.

Agronomic characteristics

Most of the varieties which were grown in the tropical and sub-tropical areas of Asia were tall, with drooping leaves. The application of nitrogen causes this type of plant to lodge and the yield, instead of going up, actually goes down. The development of an improved plant type led to the creation of IR8, the first improved variety. Among the major characteristics by which it differs from the tall varieties there is short stature, of course, and erect leaves, high tillering ability and stem sturdiness. These are the major differences between the two types that influence their ability to respond to nitrogen. Without the application of nitrogen the yields of the improved types and the traditional types are similar. We are now trying to identify genotypes which will give higher yields without the application of nitrogen. We already have some, such as IR42, which will be higher yielding than the other improved varieties or the traditional types. We are finding more genotypes which have this characteristic. Maturity is another characteristic that we are trying to alter. Most of the traditional varieties grown in the tropics needed 160 to 170 days to reach maturity. With the development of IR8 and other companion varieties the growth duration was reduced to 130 or 140 days, and now we have widely-grown varieties, such as IR36, that mature in 110 days. We also have improved lines that mature in 90 to 95 days. This improvement has made it possible to grow two crops under rainfed conditions where only one was grown before. It is now very common for three crops to be grown annually in irrigated areas in the tropics, and the possibility exists to produce four crops a year.

Grain quality

Since rice is consumed as a whole grain the quality, the appearance, size and shape of the grain are very important. Consumers are used to certain kinds of rice, preferring, for example, long, short or round grains. Chalkiness is an undesirable characteristic; what is needed is a translucent grain. There are also differences in cooking characteristics. These are determined primarily by the proportion of the two types of starches present in rice.

Disease and insect resistance

The major emphasis in our program is on stabilizing the yield potential. We feel that the yield potential of our improved varieties is more than two or three times the average yields obtained on farmers' fields in Asia. We can get 8 to 10 t./ha. under maximum management but on the farmers' fields in Asia the yield is still only 2 to 2.5 t./ha. We feel, therefore, that instead of putting emphasis on increasing the yield potential further we should stabilize this yield and try to raise the productivity on the farmers' fields. One way to do this, of course, is to incorporate resistance to diseases and insects. In the case of tungro virus, a very destructive disease, outbreaks of which occur in several countries, we have incorporated good levels of resistance into the new varieties. Tungro virus is transmitted by an insect, the green leafhopper. Resistance to the vector provides a double protection against the virus because if the vector population is low the chances of the virus spreading are limited. Another insect, the brown planthopper, transmits a disease called grassy stunt and has become a major pest of rice. There have been outbreaks of this pest in many different countries since 1970. Several thousand insects can be found on one plant because they multiply so rapidly under tropical conditions, and when the population is high entire crops, extending over many thousands of hectares, are damaged or destroyed. We have not found any resistance to grassy stunt in the cultivated varieties but fortunately we were able to locate a source of resistance in *Oryza nivara*, one of the wild species. It has one major gene which we have transferred by four backcrosses into the cultivated varieties. Another disease, known as bacterial leaf blight, is one of the major bacterial diseases of rice. Yield losses can be up to 40 or 50%. We have incorporated high levels of resistance and most of the germ plasm which is now released and grown in many countries is resistant. Another major disease of rice is blast. We have also incorporated very high levels of resistance to this fungal disease. In earlier years we used to plant our pedigree nurseries under very protective conditions with complete insecticide protection but since we introduced the genes for resistance to various diseases and insects we have been able to grow the populations without such protection. We now try to encourage the spread of diseases in our nurseries by planting susceptible rows on the outside as well as in the middle so that the test rows are exposed to full pressure. If there is not enough natural inoculum we try to ensure that the various lines are artificially inoculated with bacterial leaf blight and we endeavor to grow all the nurseries starting from the F_1 up to the observational trials under unprotected conditions. So far, we have managed to incorporate resistance to four diseases and four insects into the newer varieties. IR26 or IR28 or IR36 are resistant to blast, bacterial leaf blight, tungro virus, grassy stunt, green leafhopper, brown planthopper, stem borer and gall midge. The earlier varieties, such as IR8, were only moderately resistant to green leafhopper and were susceptible to most of the other diseases and insects.

Adverse soil tolerance

In addition to disease and insect resistance we are trying to incorporate tolerance or resistance to various stresses, for example to salinity which is very common in major rice growing areas. We have been able to incorporate a very good level of tolerance to salinity, thus making it possible to grow rice in many areas where before it was not feasible to do so.

Drought tolerance

Fifty percent of the world's rice is grown under rainfed conditions and very severe damage occurs in many areas because of drought. In parts of India where there is a very short growing (rainy) period of about 90 days the crop has traditionally suffered from drought stress. A further 15% of the rice area is situated in upland regions where drought is also a very common problem. Very good levels of drought tolerance have been introduced into lowland types and we are trying to develop improved varieties suitable for upland areas.

Deep water and flood tolerance

Conversely, we have problems with too much water. Flash floods coming from the mountains can submerge a crop for days and totally destroy it. Or we get standing water several feet in depth where only floating types of rice can be grown. We have already introduced our first improved variety for such deep water conditions and we have a major program to improve excess water tolerance.

3. Disciplinary research

Disciplinary research complements the improved germ plasm development effort. We are continually developing and improving screening techniques for disease and insect resistance or for tolerance to physical stresses, to enable us to identify the donor parents. There is a lot of variation in disease and insect pests, for example in blast and brown planthopper, and we try to discover the variation patterns in different countries so that we can find which varieties or which genes will be effective against the local races and biotypes. There are also studies on the mechanism of resistance or tolerance, whether it is biochemical or morphological. We also study the genetics of resistance because with this information we can determine which breeding methodology or breeding procedure to adopt. Furthermore, we do research on breeding methodology such as tissue culture or other techniques that might be utilized in crop improvement. We are trying, for example, to use tissue culture for selecting for increased salinity tolerance by exposing large cell populations in a culture medium containing salt or by using anther culture where we can produce large numbers of haploid plants which, by doubling, can produce the homozygous lines in one step. That, of course, reduces the time from making a cross to getting a homozygous line from almost three years to less than one year. However, there are still a lot of problems. Some varieties are easy to process through this method and others are not. Another area being investigated is hybrid rice. We have very good evidence that we can get a yield advantage of 20 to 30% with the F_1 hybrids. We have evaluated many hybrid combinations and one of them gave a yield of 10.4 t./ha., thus providing a yield advantage of more than 30% over the conventionally grown varieties. We have obtained some materials utilized in China for producing hybrid rice. We are also testing the feasibility of large scale F_1 seed production in the tropics and it should be possible to produce hybrid rice in the next two to three years.

4. Training

Training is the fourth component of our program. We have various kinds of training programs. We have degree training programs where rice breeders come from the developing countries to study for MSc or PhD degrees. They do the thesis research at our Institute and the course work at the nearby University of the Philippines which awards the degree. We have at present 17 students who are doing either Masters or PhDs in our program. Then we have a formal GEU training course which is run for four to four and a half months, twice a year. We take young breeders, about 30 or 35 in number, and offer them formal training during which they attend lectures and carry out field work. We also have specialized training which is a non-degree, non-formal training in such topics as seed production or grain quality analysis. We also have four or five postdoctorate researchers working on specialized areas such as tissue culture or areas where we might need assistance. We have trained 282 young breeders during the last six years of our program. Many of them come, of course, from the major rice growing countries, such as Bangladesh, China, Indonesia and India, and from Pakistan and Sri Lanka. We also get visiting scientists from the rice growing areas who come for one or two years, so we have a very large training program to build up the expertise needed for rice improvement.

5. International collaboration

International collaboration is, of course, an essential component of our program. All the research findings, all the germ plasm which is developed, must be shared with our collaborators in the national programs. Like CIMMYT, the work of which has been very effectively described by my colleagues from Mexico, IRRI has a very large international testing program which involves the exchange of early generation materials right from the F_1s and F_2s and segregating early generation lines. We are frequently asked by breeders in developing countries to make crosses. We send them the F_1s or grow the F_1s and send them the F_2 populations. As far as fixed lines are concerned the international nurseries are also helpful in exchanging materials. We also exchange materials under collaborative research projects aimed at determining the biotypes and races of insect and disease organisms. These then are a number of ways in which improved germ plasm is exchanged. Each year we distribute some 80 to 90 thousand germ plasm samples, including materials from our germ plasm bank, improved breeding lines and segregating materials. Through the international nurseries we facilitate the exchange of materials from one national program to another; for example, a good line developed in India can be put in the international nursery for distribution to other countries and in this way Indonesian breeders may have the opportunity to obtain lines from India and vice versa. We also have yield nurseries which include 30 to 35 of the very best entries, grown in replicated yield trials, and observation nurseries which are grown in unreplicated trials. We have disease and insect nurseries containing 300 to 400 entries and these are grown under disease and insect pressures to identify donor parents and to determine variation in disease and insect organisms. We have environmental stress nurseries, such as salt or alkalinity tolerance nurseries, and the results of these are summarized. These international nurseries are grown on a world-wide scale. Since China recently entered our international testing program all these nurseries are now also grown in China. The reports of these nurseries are published and shared with our collaborators in all the rice growing countries.

REPORT OF DISCUSSIONS

prepared by the Office of the Union
and approved by the speakers

1. The lectures were followed by a wide-ranging discussion which was presided over by Dr. W. Gfeller, President of the Council of UPOV. Dr. Gfeller was assisted by a panel comprising the five speakers (Mr. J. Huet, Dr. R.L. Paliwal, Dr. A.R. Klatt, Dr. C. Mastenbroek and Dr. G.S. Khush), Dr. J.P. Srivastava (Leader of the Cereal Improvement Program, International Center for Agricultural Research in the Dry Areas--ICARDA), and Dr. H. Mast, Vice Secretary-General of UPOV.

2. The President said that he was sure that he could speak for all the delegates in thanking the lecturers for their interesting and thought-provoking papers. He then invited questions to the panel.

3. Mr. Jenkins (Scientific Adviser for Plant Breeding and Genetics, Agricultural Research Council, United Kingdom) said that he was intrigued to hear that Dr. Khush had a program for working on hybrid rice. It had been stated during the lecture on CIMMYT that the policy of CIMMYT in regard to its maize program was to release not hybrid varieties but open-pollinated populations. Why then should it be thought necessary in a normally self-pollinating crop like rice to work on hybrid varieties? Mr. Jenkins would have thought it to be against the general philosophy of the international centers to develop varieties needing a certain degree of sophistication in their production.

4. Dr. Khush said that he had failed to mention one thing, namely that IRRI no longer released varieties. It had done so until 1975 but had then changed its policy in that respect. Now, only improved germ plasm was supplied to cooperators through means such as the international nurseries. If a suitable line was found by researchers working, for example, under a national program, then it could be released under a name chosen by them. Only 23 'IR' varieties had been released but more than 100 IRRI-bred lines had been released in various countries via the national programs and under 'national' names. Dr. Khush went on to say that with regard to hybrid rice, IRRI was just trying to develop the component lines (maintainers, restorers and male-sterile lines). These could be made available to national programs and IRRI felt that in those areas where the management was good, where the level of technology was high, where yields were already very high (5 to 6 t./ha.), that was one way of increasing the yield potential by a further 20 to 25%. IRRI would not itself release any hybrid varieties.

5. Mr. Kelly (United Kingdom) remarked that what had just been said seemed to indicate a slight difference in approach depending on the target at which plant breeding work was aimed. He said that if he had understood Dr. Khush correctly, IRRI was aiming its most stable varieties at those areas where there was highly developed technology, enabling that sort of variety to be handled. In listening to Drs. Paliwal and Klatt, he had gained the impression that CIMMYT was seeking to make available to developing countries less stable material, which could be adapted easily to a less sophisticated method of farming. Mr. Kelly wondered whether Drs. Paliwal and Klatt would care to comment.

6. Dr. Khush said that he hoped that he had not given the impression that IRRI was releasing only stable varieties. As he had mentioned, germ plasm was being provided from very early generations (from F_2 to F_4). Lines were sent to the national programs in which selections could then be made from them. IRRI did not really differentiate on the basis of the degree of technological development. Most of the rice-growing areas were collaborating with IRRI and lines, which were sent out at different stages of uniformity and stability, were available to whoever wanted them. There was not really much difference between the CIMMYT and IRRI approaches on that score.

7. Dr. Klatt said that CIMMYT also directed its attention to all types of national programs, some of which were well advanced, while others were just beginning. Material had to suit the needs of individual countries. Work was directed more towards factors such as agronomic type and disease resistance. National research programs that were quite well advanced would use to a greater extent the materials that were still segregating; less-developed programs would make greater use of CIMMYT screening nurseries and yield-trial material.

8. Dr. Paliwal noted that both Dr. Khush and Dr. Klatt had explained that there was really nothing more than perhaps a slight difference in emphasis. Unfortunately, maize was grown in the tropical world largely as a subsistence crop. It was grown as a rain-fed crop, under hot and humid conditions, where nothing was really under the farmer's control. As Dr. Klatt had mentioned, CIMMYT concentrated largely on increasing yield stability. There was a big difference between the yield levels obtained at the experimental stations and those achieved in the fields where maize production took place. CIMMYT also realized that maize production had to increase not only in the developing countries and under poor farming conditions but also in more fortunate areas where yields were already high. Whatever assistance CIMMYT could possibly provide should be quite useful. He said that he had not had time in his lecture to go into all the details, but CIMMYT was developing broad-based temperate gene pools where it was thought that even those areas where temperate maize was grown (and where a comparatively narrow genetic base was presently being used) could be helped. That development work would serve not only the temperate areas of the world but would help to provide a mechanism for transferring the "superior-yield" genes from the temperate germ plasm to the tropical germ plasm. He did not wish to expand on what his colleagues had said regarding hybrids, but just wanted to say that CIMMYT was not against hybrids. CIMMYT materials and those of national programs were being used for the development of hybrids by very strong programs, where the infrastructure, capabilities and seed production facilities existed.

9. Mr. Murphy (United Kingdom) said that he was very interested in Mr. Huet's remarks about the role of the State plant breeders in France. He understood Mr. Huet to have said that the role of the public-sector breeders in that country was one of assisting the private-sector breeders in so far as that was possible, rather than one of competing with the private sector, and that the State only became involved in breeding commercial varieties where the private sector did not have sufficient expertise. He asked whether Mr. Huet could perhaps say whether there had been a change in policy in France in recent years. Everybody was aware, of course, of the very well-known INRA varieties which had been in commerce for some time. He wondered whether the policy as described by Mr. Huet was evidence of a fairly fundamental change of attitude in France with regard to the roles of the public-sector and private-sector plant breeders.

10. Mr. Huet thought that INRA, as a public institute, had to be able to adapt itself in line with the development of the private sector. Shortly after the Second World War, for example, it was INRA that had taken the initiative in creating the first varieties of early maize, which were intended to enable maize to be grown in northern France. That had proved very successful. Now, however, there were some private breeding firms which were qualified to carry out original and effective plant breeding work for the improvement of maize. In view of that development, it was no longer necessary for INRA to give priority to the selection of hybrids. It had to go back to the earlier stages of research, first creating good lines and putting them at the disposal of private firms, which could then select combination formulas to produce high-performance hybrids. And perhaps it could then go still further back and work on the base populations, for example by introducing tropical maize genes into temperate populations, or by using tissue culture to establish maize lines more rapidly from anther cultures, etc. He did not therefore wish to give the impression that there had been an extreme change of policy in France: it was no more than progressive adaptation to the development of the private sector and to its potential for effective variety creation work.

11. Mr. Fikkert (Netherlands) said that he had two questions but was not sure to whom he should direct them. It was possible that they related to all the lecturers. First, he wondered whether a private breeder, who was supposed to develop material from the public breeder into commercially suitable varieties, should be able to obtain exclusive rights in those varieties. Secondly, if he were able to obtain exclusive rights, was there a risk that such a practice might frustrate public breeders?

12. Mr. Huet said he had not fully understood the sense of Mr. Fikkert's question. He wished to know whether it concerned semi-finished material intended for breeding work, or commercial varieties, created by a public service, the multiplication of which was entrusted to a private firm.

13. Mr. Fikkert replied that he had meant the first case, where the material released by the public breeder had still to be refined and finalized into commercially suitable varieties. The second question was whether, if a private breeder were able to obtain exclusive rights in those varieties, which he was making from the material released by the public breeder, there was a risk that that might frustrate the work of the public breeder.

14. Mr. Huet said that if frustration meant the researcher's impression that he had been denied the satisfaction of having put a finished variety on the market, there were indeed and always would be researchers who felt that frustration. However, as a public service, INRA was not concerned with its researchers' feelings, but rather with serving the national community. And the problem was not even one of serving the seed industry through one firm or a small number of firms, but rather one of serving farmers, processors and consumers as a whole. There was therefore some frustration in the inability to carry research work through to the actual creation of a variety, but that was more a problem of policy, and also one of discipline; a research team could sometimes serve the public interest better by doing the initial research work that private firms could not do, than by going on to the point of creating a commercial variety. INRA's right to create varieties, a right to which it was very attached, must, however, be recognized.

15. Dr. Mastenbroek said that it was set out in the UPOV Convention and in national legislation that all varieties were freely available for breeders for further development, for the development of new varieties, which new varieties were eligible for plant variety protection. So when a private breeder received a half-product from a public institute, on which he had to do on average much more development work than if he had used finished varieties with value for cultivation and use from his colleagues (competitors), Dr. Mastenbroek saw no reason why the private breeder should not get plant variety protection for a variety based on that half-product. He added that as far as the question regarding frustration was concerned everything depended on personal attitudes. There were scientists who were much more interested in making species crosses, in making crosses with varieties from distant parts of the world and in developing half-products that could be used by the private breeders. They would not be frustrated. He knew, on the other hand, of some cases where public-institute scientists would have liked to have the possibility of finishing that material and producing commercial varieties. He repeated that it all depended on personal attitudes.

16. Dr. Klatt thought that what was being discussed was exactly the objectives in the international centers. He said that when CIMMYT distributed F_2 material they were essentially saying to public and private breeders around the world: "here is the start of something, take it and do with it as you please." But most of the material coming out of international centers that was utilized was actually advanced material, material that was essentially a variety without a name. All that was needed was to find the location to which it would be best suited. The situation was indeed sometimes frustrating because it was not possible to point and say "that's our variety." CIMMYT knew that some of the varieties marketed around the world came from material developed by CIMMYT but still CIMMYT breeders could not call the varieties their own. The international centers realized, however, that it was their responsibility to agriculture around the world to do that sort of thing. He thought it must be more difficult in national public institutions.

17. Mr. Simon (France) said he would like to enlarge on the same point, because the talk was about semi-finished products but one could equally imagine a product that was not exactly finished, because it was not sufficiently homogeneous, but in fact was finished from a scientific point of view. Mr. Simon wished to have the views of the breeders and international centers on that. Public research aimed to put at the disposal of the general public parental lines that were not strictly homogeneous, but which from the scientific point of view were practically finished varieties. That material was distributed to breeders who might derive sister-lines from it that were very similar in characteristics; if protection was then sought for those lines, it caused problems of distinctness and novelty. Where did novelty begin and end? Mr. Simon wished to know what institutes and universities thought of the problem.

18. Dr. Mastenbroek said that he understood that Mr. Simon's question concerned two sister-lines developed from a population or a part of a population with one and the same derivation, sister-lines very close to each other. He would answer that when the difference was small but still sufficient to enable the two to be distinguished according to the DUS tests, then both would get plant breeders' rights. If the difference was too small to enable them to be distinguished then the first one would get protection and the second would not. That, of course, might be frustrating for the breeder of the second 'variety' but it was all in the game. Such situations had occurred many times. They were a consequence of the protection that the breeders had asked to have, and one of the conditions that they understood had to be met by a variety before protection could be granted was that it could be distinguished. Since they had asked for protection they had to accept that two varieties had to be sufficiently distinguishable and that, if they were not, then the second would not get protection.

19. Mr. Simon said he understood that basically protection could be given to the first sister-line presented, but he wondered what should be made of that line when it was compared with the original material. While the original material was not homogeneous in terms of the UPOV Convention, it nevertheless, in general, was already fairly identifiable. Mr. Simon wished to know whether the first line presented could be protected in relation to the original material.

20. Dr. Mastenbroek said that he was of the same opinion, because material that was not homogeneous was not eligible for plant variety protection.

21. Dr. Srivastava said that, taking the question from a slightly different angle and looking at the advantages and/or disadvantages and some of the inherent problems, it appeared that a number of speakers had indicated that the public-sector institutions should come up with semi-finished products and that the private plant breeders or companies should take those to the finished products which they exploited commercially. He asked what the interests of the private plant-breeding companies were. The first one would certainly be that they got enough money (royalties). The more varieties released the better it was for the plant breeder. He wondered how it could best be ensured that the varieties to which protection was granted were truly in the interests of the farmer and of increased productivity for the nation--and not necessarily just for making money (for the breeders). If State institutions were prevented from coming up with finished products and from providing competition, thus helping to ensure that only the best material was released, was there any inherent danger that some of the many varieties released might not have that high a standard? Such a danger might be greater in some of the countries lacking strict laws and regulations to control varieties. If companies started selling seeds in those countries, that might adversely affect national research efforts. Also some varieties might be grown in a country even though they were not necessarily the best varieties for that country. He wondered how one could guard against those problems and dangers.

22. Mr. Heuver (Netherlands) said that he had been concerned recently in the preparation of an advisory paper on those matters for the Technical Advisory Committee of the Consultative Group on International Agricultural Research. Where plant variety protection currently existed there was generally also a system of good competition between private breeders and in the end the best variety won. He thought, therefore, that in general there was no problem. In situations where there were no facilities for conducting a good test of agricultural value it was possible for the industry, whether government or private, to push a variety. In his opinion, therefore, a country should first have a good seed production system, competition and a good extension service to test and give advice on new varieties so that the farmer could at least make a choice from the available varieties. In such countries it could be of value to stimulate private plant breeding by providing for plant breeders' rights so that part of the revenues from seed sold were made available for further plant breeding activities, as already happened in many countries. He added that it might be an opportune time to raise another question. Mr. Huet had said in his lecture that the distribution of breeding material from a government institute in France, namely from INRA, was restricted during a certain number of years before being given to private industry, perhaps not to foreign breeders initially, to give the breeders' organizations in France a possibility of keeping somewhat ahead of others. Participants had also heard the paper of Dr. Paliwal and Dr. Klatt, who had stated that CIMMYT distributed

material as soon as possible all over the world to all who wished to have it. Bearing in mind Mr. Huet's remark that "one must give in order to receive," did the international centers experience any difficulties in obtaining breeding material at a reasonably early stage, either from private breeders or from government institutes in countries where there was a system of plant breeders' rights or where a competitive situation existed?

23. Dr. Mast remarked that in recent times he had frequently been confronted in various parts of the world by the assertion that private firms appropriated and, with the help of plant breeders' rights, monopolized breeding material from international breeding centers. An examination of the individual cases showed that most of the incidents involved had in fact occurred in countries where there was no plant variety protection at all. The problem, if any, had little to do with plant variety protection, and in fact little could happen in a country that had plant breeders' rights legislation. In his view, in such a country, there were two guarantees that prevented anyone from appropriating breeding material; for example, if an international breeding center released a finished variety which was ready for the user, that variety would be a matter of common knowledge in such a country. Of course it would be a matter for national jurisdiction or legislation to determine what constituted "common knowledge," but as a rule the variety would be considered commonly known when released, and protection was only granted for new varieties which could be distinguished from commonly known varieties by at least one important characteristic. It was for that reason that a private firm trying to appropriate a finished variety would have no success with the authorities. There was also another factor which ought to prevent such a firm from succeeding, namely that the firm was not the breeder, and in most of the national laws that conformed to the UPOV Convention, if not in all of them, only the breeder or his successor in title could obtain protection. On the other hand the participants had heard from the lecturers that there were cases where international breeding centers released material that was not finished and still needed improvement, in other words varieties for which private parties, private breeders or national public breeders would have to continue the breeding process. In such cases it would of course be possible for whoever developed that half-finished variety into a true variety to be granted protection, once the variety in question had become sufficiently distinct from the commonly known material released by the international breeding centers. In that case the private firm would be considered the breeder and could not be denied protection.

24. Dr. Klatt said that there were many differences in the definition of "uniformity" between developing countries (and even in Mexico), and Europe. What CIMMYT would release as a variety in Mexico, or in Algeria or in India, probably would not meet European standards. He referred back to the discussion surrounding the question about sister-lines posed by Mr. Simon, and asked whether private companies could release 'near-varieties.' For instance, most of the lines distributed by CIMMYT in the screening and yield nurseries would be sufficiently uniform to be released in most developing countries. They would not be uniform enough, however, to be released in Europe. He asked whether, if a private company purified such a 'variety,' the 'purified variety' could be protected.

25. Mr. Simon said that he was able to answer for France. Great care was taken with that kind of problem when his office received a sample of material developed from a well known nearly-finished variety. His experts were careful to establish who was the true breeder. So far, each time such material had been presented, the outcome had been the same, namely withdrawal of the application. That was very important since it followed that material from institutes, such as CIMMYT, even if it did not correspond to the generally accepted conception of homogeneity and so qualify for a breeder's certificate, was included, at least whenever possible, in the range of varieties serving as a comparative basis for determining the novelty of varieties for which applications were filed. In other words, the CIMMYT material, if known, listed and described, was to some extent "protected" against being appropriated, in the same way as all varieties that were public property. That was a fundamental point in order not to encourage that kind of "lifting" of varieties through the granting of certificates.

26. Mr. Murphy said that the situation in the United Kingdom was very similar. If anyone took such material and applied in the United Kingdom for plant breeders' rights he would have to state on his application form the name of the breeder of the variety in question. If the applicant had simply 'purified' the material he would not be right to claim that that constituted the

breeding of the variety. If he made a false statement on his application form, claiming that he had bred the variety, he would be subject, if found out, to proceedings in respect of that criminal offense. Furthermore, if a title of protection had already been granted it would be taken away because of the false statement. He added that he would have thought that only a rather foolish company would go to such lengths, since there had to be a fair likelihood that it would, in the end, be found out, and that would damage its commercial reputation very severely.

27. Dr. Klatt remarked that it did, however, happen. He said he would not name the company but he could give an example. CIMMYT had recently received a request for the complete pedigree of a durum line sent out in a screening nursery. The complete pedigree had been sent. About a month later the same company had written again, asking for a complete description because they wanted to apply for a title of protection.

28. Mr. Heuver said that there was a difference between applying for and getting protection. What had been said by representatives of the plant variety protection offices of France, the United Kingdom and the Netherlands was that although such applications might occur, and even be initially successful, they would not succeed a second time. A look at any errors which had been made in the past would show that such problems were the exception and not the general rule.

29. Dr. Klatt said that he would agree with that.

30. Mr. Fikkert said he would like to add to the discussion. The risk of errors being made by the plant variety protection authorities could be diminished if the public breeding institutes, whether national or international, were able to give sufficient publicity to the lines they released. As his country saw it, those lines were 'nearly-finished varieties.' More publicity could help in considering whether an applicant was the real breeder or not. By publicity he did not mean that public institutes had to send samples of all their nearly-finished varieties, of which there were some thousands each year, to the granting authorities of each member State of UPOV. Some other form of publicity would suffice.

31. Mr. Simon said that he had been about to put forward the same idea as Mr. Fikkert. Sufficient information was required about material from CIMMYT and other international bodies in order that work of the Offices might be carried out effectively.

32. Dr. Klatt said that CIMMYT would very much like to do what had been suggested by Mr. Fikkert, but it needed an avenue through which to publicize the material released. Some 2,000 fixed lines were distributed annually and CIMMYT had no possiblity of describing them all each year. CIMMYT had recently considered an idea, coming, he thought, from the Netherlands, that the best way to proceed might be for CIMMYT to send a complete set of those fixed lines to one of the member States of UPOV so that a check could be made against that base material whenever CIMMYT suspected that a newly released variety, similar to one of its lines, had been derived from that base material. He said that he would like to explore that idea with the members of UPOV to see if a working arrangement was possible.

33. Mr. Heuver said that the idea outlined by Dr. Klatt had been discussed but it needed further consideration. It would be impossible for UPOV member States to take all those varieties or nearly-finished varieties into their reference collections, but if they were somewhere in store, then if someone claimed that a variety in respect of which protection had been granted was in fact a CIMMYT variety, a check could be made and, in the event that the claim was justified, the right would be annulled. He felt that if such a system were worked out, if there were a need for it, then no plant breeder would operate in that way and risk having a right annulled. Plant breeders were generally not looking for protection for material that they had not worked on. Perhaps there would be an occasional mistake, perhaps one firm was trying to do that, but he thought that they would only succeed once. He did not in fact think that it would be worth spending too much money to guard against that one error.

34. Dr. Srivastava said that nevertheless the private sector should not be discouraged from making use of all available material, whatever its origin. He asked if Mr. Murphy and Mr. Heuver would clarify what they considered to be a 'nearly-finished product' and what they meant by the 'real breeder.' It was important for those expressions to be clearly understood so that the issues did not become confused. In his view the position of the international center, at least that of ICARDA, was that, when a cross was made, that was not necessarily the end of the breeding. Lines included in screening nurseries might give differing results depending on agro-environmental conditions. ICARDA's objective was that whoever was able--whether in the private or public sector--to exploit such material for specific conditions should do so for the sake of increased productivity. It would help a great deal if the line demarcating 'true breeding' by ICARDA, CIMMYT or any other international center could be fixed, and if it could be determined how much work a private plant breeder had to put into a variety to justify claiming a title of protection for it. Whilst one should be very careful in that area, one should not be over-restrictive.

35. Mr. Murphy said that he thought the explanation he had given had been in answer to Dr. Klatt's specific case, where he had said that a commercial variety had in fact been bred by one of the international centers and was in a sufficiently final form for release in certain countries but did not meet the uniformity standards for marketing in, perhaps, the United Kingdom. In those specific circumstances he thought that the courts, which would eventually be dealing with the matter, would come to the conclusion that that variety had been bred by the international center and that the simple act of purification, which might take only a year or perhaps two years, did not represent breeding in the legal sense. He thought that the other case, where a breeder had genuinely improved or modified a variety, was quite different, and in those circumstances imagined that the courts would regard the work done by the subsequent breeder as genuine breeding work.

36. Dr. Klatt said he would like to clarify one thing. When CIMMYT released F_2 populations, that was the means by which it tried to distribute germ plasm to all the breeders of the world. F_2s were made available to everyone. Very little breeding work had been done with them but there had been a great deal of data accumulation and an effort to make the right combinations. Anyone, private companies included, was free to utilize those F_2s as they saw fit and to claim that material. His earlier reference had only been to what CIMMYT called advanced lines, which he thought many of those present would probably call near-varieties because they were not uniform enough for their standards. That was one of the reasons why CIMMYT had restricted germ plasm distribution to private companies to F_2s because they could utilize all the material in the system and develop their own varieties. Now if a private company requested certain breeding material, CIMMYT would provide that also, but only for breeding purposes.

37. Mr. Mathenge (Kenya) said that it was not very clear to him from the presentations by Dr. Paliwal and Dr. Klatt whether, within the mandate of international agricultural research centers, and in particular of CIMMYT, it was possible to make a further contribution other than just the dispatch of germ plasm for exploitation by national programs. He knew that in many national programs the major limiting factors were lack of expertise to exploit the germ plasm for the development of new varieties, and finance. He wished to know whether it was possible for a national government to enter into a bilateral agreement with an international agricultural research center for expertise and finance, rather than the traditional bilateral agreements between governments. That question related in particular to a country that hosted a regional office of an international agricultural research center.

38. Dr. Klatt replied that as far as expertise was concerned CIMMYT made a great effort to train national scientists. That was one of its prime objectives. There were various training programs, generally short-term applied training, of which he thought Mr. Mathenge was aware. Regarding the question of bilateral agreements, CIMMYT was a grant-receiving and not a grant-giving institute. CIMMYT's wheat program currently employed only 27 people around the world. Many years previously it had become evident that there were two problems in entering into bilateral agreements: one, lack of people, and two, lack of money, a common problem. CIMMYT had a philosophy that it should enter into agreements only where invited to do so. There were so many requests from governments that it was impossible to handle all of them. As a result a regional approach had been developed, dividing the various parts of the world

into regions with more or less common problems, and work with national programs had been coordinated through regional offices. For that purpose CIMMYT had established six such regions and every effort was being made to staff the regional offices adequately. The optimum would seem to be three people at each regional office. There were still rare instances where CIMMYT entered into bilateral agreements. That had to be done, however, with what in the CGIAR system was called 'special money.' The money was not available within the core program. If a donor came to CIMMYT and offered money for work to be done in a particular country, with a staff of two or three people, then CIMMYT had the possibility of responding. Otherwise, it was very difficult to respond to the request of an individual country, primarily because of the limitations on staff and money. CIMMYT's regional staff always worked within the national programs. The purpose of the regional office was to make the best possible use of the staff and resources available. There were drawbacks. It was not possible to put all the emphasis on one country or always to station people where they were most needed. CIMMYT believed that the regional concept would work even though it would probably take somewhat longer.

39. Mr. Espenhain (Denmark) said that if he had understood correctly the international breeding centers generally restricted the material released to private breeders to F_2 material. He wondered whether the rare problems one had heard about had given rise to thoughts of further restrictions. He also wished, in that connection, to hear what kind of material the international breeding centers were using as a basis for their screening work and for breeding their 'near-varieties.' What kind of material did they get, for example, from other gene banks or from private or government breeders?

40. Dr. Paliwal said that as far as maize was concerned, and as far as the general philosophy of CIMMYT was concerned, the limitations mentioned by himself and Dr. Klatt were not based on the problem incidents referred to. The restrictions were forced on them because of the limited availability of material. He had mentioned, for example, the maize families or progenies that were generated in each cycle from the populations. They could only be sent for evaluation to six locations, because there were only about 300 kernels of each family available. When experimental varieties were generated there were sizeable quantities of seed, and no restrictions were imposed on availabilty. For as long as there was a stock it was available to all who requested a sample. When supplies were short first preference was given to collaborators in the national programs but, if stocks sufficed, then the material was available to private breeders.

41. Dr. Klatt said that some six or seven years previously CIMMYT had distributed even 'fixed lines' from the wheat program to private companies. Because of a few unfortunate instances it had been decided to restrict distribution to F_2 material. He did not foresee that policy changing. CIMMYT believed that if a national program or an individual breeder or breeding company developed something from an F_2, then they were the breeder of that resulting material. Regarding sources of germ plasm, CIMMYT endeavored to work with as wide a germ plasm base and with as much variation as possible. He believed that the variation in the CIMMYT wheat program was as large as or larger than any other program in the world. It was not able to restrict itself to the problems found, for example, in Mexico, and had to consider a very wide range of problems such as Septoria nodorum, S. tritici, Helminthosporium, Barley Yellow Dwarf Virus, three Rusts, and Scab. For that a wide genetic base had had to be maintained. Material, including winter wheat material, was received from many national programs, most of which cooperated very well, supplying whatever material was requested. There were no difficulties in importing the material into Mexico. He believed, however, that CIMMYT lacked material from private companies. He felt sure that there was a lot of material out there which CIMMYT could utilize effectively. What was normally received was varieties two to five years after their commercial release. Those varieties were normally used in breeding programs. The CIMMYT wheat program was concerned solely with spring wheats, in other words wheats that would probably not be suited to the general environment in most of the member States of UPOV.

42. Dr. Khush said that IRRI was working in a part of the world where there were no such companies, at least as far as he was aware, for rice. To the best of his knowledge IRRI had never received any request for material from a private company. It occurred to him, nevertheless, that even if the policy was not to supply seed of breeding lines, companies could still obtain such material if they really wished to do so. The international testing program required the seed to be distributed all over the world and companies might be able to acquire samples from another breeder.

43. Dr. Srivastava said that the crops dealt with by ICARDA were food legumes, forage crops and winter cereals. The policy was similar to that of CIMMYT in respect of maize, as indicated by Dr. Paliwal. Depending on the availability of germ plasm, the first priority was to supply national programs in developing countries, the second to meet any requests received from public-sector organizations and then, if stocks were not exhausted, seed was made available on request to private-sector organizations. That policy applied equally to F_2s and to screening lines. In return ICARDA had received very good cooperation from private companies. There were exceptions but, by and large, once varieties were released they sent samples and they were used by ICARDA in its crossing programs. As yet there was no hard and fast regulation that international centers would not, as a matter of policy, supply material beyond the F_2 generation.

44. Dr. Mast asked whether there were any safeguards to ensure that the material released by the international breeding centers was not used in an improper way. If, for example, a variety or near-variety were transferred to an unsuitable climatic zone where it did not grow well, that would damage the reputation of the variety and might prejudice its use in other parts of the world. He wondered if there were any conditions or warnings attached to the release of material.

45. Dr. Klatt said that CIMMYT normally distributed material only to areas where it could be utilized. Spring wheats, for instance, were not sent into winter wheat areas unless a cooperator made a specific request to that effect. Materials were sent to the Federal Republic of Germany, to Belgium, to Holland, but they were being utilized for crossing purposes, probably in making spring X winter crosses. Most cooperators were familiar with the material, having been receiving supplies for many years. CIMMYT was making efforts to be more selective in what it sent out, and hoped to succeed in the near future. The aim was to ensure, for example, that material with known or potential resistance to Septoria or to Helminthosporium got into the areas where those diseases were a problem. CIMMYT's objective was to develop broadly-adapted materials which would do well over a wide range of conditions. As he had already mentioned, the cross 8156, which had done very well in Mexico, had been released as Kalyansona and Mexipak 65 in India and Pakistan and had probably been released in 20 other countries. Another example, ANZA had been released in some ten or twelve countries ranging from the United States of America (California) to Sudan, South Africa, Zimbabwe, etc. There was a new breeding line, known as Veery, which was expected to be released all over the world. As could be seen, CIMMYT was breeding for general rather than specific adaptation.

46. Dr. Paliwal said that it was necessary to consider Dr. Mast's question from two points of view. First there was the distribution of material for research purposes, and secondly there was the distribution of material for the purposes of production or ultimate use. CIMMYT liked to establish the extent of the range of adaptability of the materials it was developing. One population of Central American origin, for example, known as Tuxpeño-1, was now being cultivated on thousands of hectares in China. For such purposes CIMMYT needed to establish the range of adaptability of its materials as it developed them. As materials were progressively improved so the range of adaptability widened. For those purposes materials were pushed to their limits, but the maximum possible caution was still exercised. Several countries in Europe were cooperating with CIMMYT to determine the range of adaptability of the new broadly-based temperate X tropical gene pools that it had developed. The examples he had just given all came under the distribution of material for research purposes. As far as materials such as experimental varieties or elite varieties were concerned, CIMMYT made every effort to see that they were only distributed in parts of the world where, considering their known adaptability, they were bound to be relatively successful.

47. Dr. Srivastava said he would like to express his concern in respect of the matter raised by Dr. Mast. He felt that there was a danger that some of the varieties which, after a few years of tests at a few locations, appeared to be outstanding, might be released without adequate testing by private breeders lacking a network for testing at a large number of locations over several years. His concern was that in that case, especially if a variety became susceptible to one or more diseases, problems might be caused. The wheat cross 8156 mentioned by Dr. Klatt, for example, known also under many other names such as S227, Mexipak and Siete Cerros, which had done so well in

many places, when released in Morocco proved a dismal failure simply because it became susceptible to Septoria. All he was saying was that great care was needed when varieties were promoted in countries where the infrastructure was not sufficiently developed to enable the material to be tested.

48. Mr. van Wyk (South Africa) said that he would like to ask Dr. Mastenbroek to tell participants what the general attitude of private plant breeders was towards public institutes obtaining protection for varieties they had developed. He knew that in many cases the institutes would like to be able to collect royalties, thus providing themselves with additional funds for further research work.

49. Dr. Mastenbroek replied that he thought the professional breeders had little or no objection to that. The situation already existed in Europe and was not at all uncommon. He said that, to be frank, private plant breeders looked on it as rather 'heavy' competition, but he pointed out that a number of public breeding institutes and their commercial marketing organizations were among the members of ASSINSEL.

50. Mr. Rigot (Belgium) said that Mr. Huet had described how a public body such as INRA could aid private breeding organizations. He therefore wished to know whether the private breeding firms that were members of ASSINSEL collaborated between themselves, offering mutual aid of a scientific nature, and whether private firms exchanged information, or whether such firms pooled their resources to achieve breeding results.

51. Dr. Leenders (ASSINSEL) said that cooperation between private breeders usually took place at the national level. In several of the member countries of ASSINSEL the breeders came together to discuss their technical problems. Public breeders were also frequently present at such discussions and, as a result, the public breeding stations were well informed about the work done by private breeders and about their wishes regarding, for example, fundamental work to be done by the State. Because it was generally a two-way exercise, private breeders were similarly informed about the work and aspirations of their public counterparts. He could well remember, for instance, that all the breeders in one specific country had decided to start a collection of material of grasses. At the end of the project the material had been shared out and analyzed by the public and the private sector, both of which profited from the initiative. At the international level cooperation of that kind was made more difficult by such factors as differences in climate and language. ASSINSEL had in fact organized a symposium in Denmark a couple of years previously on specific questions relating to electrophoresis. An exchange of information had taken place between private breeding companies and representatives of some of the plant variety protection offices. At the international level such cooperation was normally ad hoc in nature whereas the cooperation at the national level between plant breeders, usually both private and public, was more institutional. He was proud to be able to say that in some of the member countries of ASSINSEL cooperation between the two sectors was working very well.

52. Dr. Mastenbroek remarked that, by way of addition to what Dr. Leenders had just said, he knew of cooperation at the national level between two independent Dutch breeders who had a joint program for breeding winter and spring wheats and barleys, whilst maintaining their own individual programs, on the one hand for grasses and on the other for winter oilseed rape. There were also a few examples of cooperation at the international level. He knew of the existence of arrangements between breeders in Belgium, France, the Federal Republic of Germany, the Netherlands and the United Kingdom, who exchanged samples of material at an early stage--not populations but selections from individual plants taken from F_3 or F_4 populations, which were, of course, not yet completely stable fixed lines--for testing in each country. Sometimes a line did well only in one of the countries. If a variety evolved from such a line and plant variety protection was granted, it was still known who was the originator of that variety.

53. Dr. Klatt noted that Dr. Mastenbroek had spoken of some areas of cooperation where materials were sent back and forth. He thought that the ultimate objective of the international centers, namely to get the best variety into the hands of the farmer so that food production could be increased, was more or less in line with that of the private breeders. It was imperative that all breeders should have the chance to work with the best materials available,

with the widest possible base or the greatest range of variation that existed. One of the concerns of CIMMYT was that plant variety protection restricted the exchange of material. He believed that any breeder who was doing a good job should feel able to share his material without being concerned that he might lose it. He should be more advanced than anyone receiving the material and should still be able to release it first. Therefore, why not distribute it?

54. Mr. Simon appreciated Dr. Klatt's point of view but wished to point out that, while that protection was available in countries that were party to the UPOV Convention, breeders who had created varieties were entirely free to develop them in countries where there was no plant variety protection. French breeders certainly did not hesitate to distribute their varieties in such countries. To Mr. Simon's knowledge, all French varieties of interest were commercialized in Socialist countries, as they were in North Africa, if they were suited to those regions. Protection did not have a restraining effect on the development of interesting varieties. In his opinion, therefore, there was no problem.

55. Dr. Troost (AIPH) said he thought that the point made by Dr. Klatt was a good one but it went beyond the nature of the breeders' rights. First of all, the breeders had to create new and, if possible, better varieties. The purpose of breeders' rights was to help to give the breeders a possibility of going on with their work. In most cases breeders were also seedsmen, commercializing their own varieties, and their objective was to deliver seed of their varieties to their customers all over the world, regardless of whether or not plant variety protection existed in a country.

56. Dr. Klatt asked whether all would not benefit if there were a free exchange of material. Not just one but all breeding companies and institutions would benefit because all would be working with the very best material available and progress would be much faster. As it was at present, certain companies were able to get much more material than others and that gave them a distinct advantage. Perhaps that was the way it should be in a competitive world. But if there was a free exchange then one would see who was really the best at developing the varieties and at moving forward on the yield front and on some of the other problems.

57. Dr. Troost said that it must be remembered that the breeder was also a commercial man. When he had bred a variety it was his firm's duty to deliver it to its customers. A second point was that according to both the UPOV Convention and the national laws a variety, once protected, could be used for breeding and further research purposes. In fact the system worked and things were really moving faster than Dr. Klatt supposed.

58. Mr. Burr said that he would like to raise one other point which had not so far been mentioned, but which deserved at least to be touched upon, although there would not be time to discuss it fully. A breeder's work did not end with the creation of a new variety; under the national laws and the provisions of the UPOV Convention the new variety had to be maintained as such, and that point was somewhat undervalued, in his opinion, by the international centers, which were continually moving forward, breeding new and better varieties. That, of course, was very important, but in the interests of farmers it had also to be ensured that an existing variety remained stable for say six, eight or ten years. Farmers would first gain experience by growing a new variety for two or three years and would then like to grow the variety for a further six to eight years, until a significantly better variety came on to the market. Until that happened, they would like identical material to be available. Those involved in the maintenance of varieties should receive compensation for their efforts. Mr. Burr saw breeders' rights at least partly as a compensation for the work of maintenance breeding and not exclusively as compensation for the creation of new varieties. He believed that to be a point that should be considered further on some future occasion.

59. Dr. Klatt said that earlier in the discussions a number of speakers had indicated that advanced lines developed by international centers would be protected. Why could the same system not be applied to advanced lines developed by private companies? Wider distribution of such material would be very valuable. It would give a broader genetic base from which to work and, provided that the material was protected, individual companies would be assured that the lines they distributed were not going to be stolen by other private companies. The potential for incorporating new resistance, better adaptation and many other things would be greatly expanded.

60. Dr. Mastenbroek said that a private breeder paid all the costs of his work from his own pocket. It was not unreasonable that he should expect an appropriate remuneration from those who benefited from growing his variety. In the past, without plant variety protection, a private breeder who developed a promising variety multiplied it for some generations until he had a suitable quantity of seed--perhaps, in the case of a cereal variety in certain countries 1,000 t. or more--and then he launched the variety. For as long as he was able to maintain his position as the exclusive supplier of the variety the breeder could add a premium to the price to help cover the breeding costs. After two or three years, however, the variety would inevitably become available to everyone and the possibility of recovering breeding costs by way of premiums would no longer exist. In Western Europe the present situation, under the plant variety protection system, was that the breeders had reached the stage where they looked upon one another much more as colleagues than as competitors, to the point where they had a joint testing system into which each breeder put two or three of his best selections from the previous years. Each breeder tested all of the new selections entered against existing varieties. In that way a great deal of information was established even before applications were made for plant variety protection. So, in fact, it was already the practice for promising material to be exchanged between competing breeders even before applications for protection were made. The colleagues trusted each other not to select from the lines exchanged, which might not be completely uniform, but they accepted that those new, as yet unprotected, lines might be used for crossing purposes. All that was the result of plant variety protection.

61. The President closed the Symposium by again expressing his appreciation of the papers given and by thanking all who had participated in the discussions.

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INTERNATIONAL ASSOCIATION FOR THE PROTECTION OF INDUSTRIAL PROPERTY (AIPPI): G.E. Kirker

INTERNATIONAL ASSOCIATION OF HORTICULTURAL PRODUCERS (AIPH): R. Troost

INTERNATIONAL ASSOCIATION OF PLANT BREEDERS FOR THE PROTECTION OF PLANT VARIETIES (ASSINSEL): C. Mastenbroek; H.H. Leenders; J. Gallart; J. Jørgensen; R.C.F. Macer; R. Meyer; J. Molina; C.P. Pedersen; P. De Wenetz; J. Winter

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INTERNATIONAL CENTER FOR THE IMPROVEMENT OF MAIZE AND WHEAT (CIMMYT): A.R. Klatt; R.L. Paliwal

INTERNATIONAL RICE RESEARCH INSTITUTE (IRRI): G.S. Khush

VI. OFFICER: W. Gfeller (President of the Council)

VII OFFICE OF UPOV: H. Mast; M.-H. Thiele-Wittig; A. Wheeler; A. Heitz

CALENDAR

UPOV Meetings

1983

April 26 and 27	Administrative and Legal Committee
April 28	Consultative Committee
May 31 to June 2 Zaragoza (Spain)	Technical Working Party for Vegetables (Subgroup on May 30)
June 8 to 10 Skaelskør (Denmark)	Technical Working Party for Agricultural Crops (Subgroups on June 7)
September 21 to 23 Rome (Italy) or Santa Cruz de Tenerife (Spain)	Technical Working Party for Fruit Crops (Subgroup on September 20)
September 27 to 29 Conthey or Wädenswil (Switzerland)	Technical Working Party for Ornamental Plants and Forest Trees
October 3 and 4	Technical Committee
October 11	Consultative Committee
October 12 to 14	Council
November 7 and 8	Administrative and Legal Committee
November 9 and 10	Hearing of International Professional Organizations

The International Union for the Protection of New Varieties of Plants (UPOV)--an international organization established by the International Convention for the Protection of New Varieties of Plants--is the international forum for States interested in plant variety protection. Its main objective is to promote the protection of the interests of plant breeders--for their benefit and for the benefit of agriculture and thus also of the community at large--in accordance with uniform and clearly defined principles.

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