Flower breeding for the global market

UPOV Symposium on the plant breeding of the future

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Introduction: Complexity of the flower market

- Different segments
  - Cut flowers
  - Indoor plants
  - Bedding plants
  - Perennials
  - Grasses
  - Shrubs
  - Trees
- Wide range of species with a commercial value
- Propagation technology
  - Seeds
  - Cuttings
  - Bulbs
  - In vitro material
  - Grafting

- In Europe
  - 400 species
  - 250 genera
  - 100 families

Introduction: Company profile Selecta

- Family owned company group with 10 companies focussed on breeding, young plant production and distribution of vegetative propagated ornamentals
- Breeding: approx. 45 species
  - bedding plants, pot plants, perennials and cut flowers
  - 7 breeders located in Germany and Italy
  - Breeding facilities in Germany, Italy, Tenerife, Kenya
  - Laboratory for in vitro culture, biotechnology and phytopathology in Germany
- Production of unrooted cuttings in Kenya, Uganda and Tenerife (30 ha)
- Rooting facilities in Germany and Italy (15 ha) plus contract rooting in 8 European locations
- Distribution worldwide throuh sales reps, agents, root and sells, wholesalers and licensees

Germany

Italy

Tenerife

Uganda

Kenya

The global flower market

- Total retail value approximately $ 100 billion
- Cut flower segment $ 40 to 60 billion
- North America, Europe and Japan are 80% of the market
- Cut flower markets are declining
- The outdoor segment is moderately growing
- The cut flower market is dominated by vegetative propagated species
- The fast majority of protected varieties are vegetatively propagated

The global flower market

- Floriculture is in a heavy consolidation process driven by price pressure in retail which effects also the breeding companies
  - In the last years we saw a number of mergers and aquisitions
  - Breeders and young plant producers relocated their mother stock, seed production and tissue culture to low cost countries
  - The fast majority of the breeding activities is still located in North America, Europe and Japan
  - Despite consolidation, there is an impressive number of small breeding companies and private breeders who achieve very frequently important breeding results
    - Huge diversity of ornamentals
    - Enthusiasm achieves sometimes more than professionalty
    - The technical level of breeding is in many species still low

The global flower market: Trends in gardening

- The classical plant classes like bedding plants, perennials, shrubs and even vegetables are blurring
- Having a nice garden or patio is in, working in a garden is out
  - „Do it myself“ is becoming „Do it for me“
  - Decorating is taking over gardening
- Breeders have to provide solutions
  - Recipies for plant mixes
  - Mixed pots
  - Not the single variety but the combination of varieties has to perform

The global flower market: Impact of marketing

- The introduction of Surfinia changed the bedding plant market in Europe:
  - Innovated breeding was combined with a strong marketing approach
  - Surfinia became a synonym for all trailing Petunia
  - Surfinia is today one of very few brands in our industry which achieved a certain level of consumer recognition
- Today innovative marketing is nearly always combined with a strong marketing approach and the success of breeding is highly depending on the marketing behind it
- The retail demands today from the breeder a package of new varieties and marketing tools

Conventional breeding approaches: Bedding plants

- The bedding plant market is driven by the indroduction of new commercial products which can be a new hybrid, a new species or even a new genera
- The novelties take marketshare of the existing commodities and can develop into a major product within a few years
- A good example is the genus Calibrachoa
  - First varieties were introduced by Suntory 1996, before that Calibrachoa was not known as an ornamental
  - Today Calibrachoa is already the second biggest vegetative propagated bedding plant in North America and also in Europe and in Japan the product is already a major genus with a strong growth year by year
  - At least 8 companies have established breeding programs and release improved varieties yearly

Conventional breeding approaches: Bedding plants

- The breeding of bedding plants was driven by innovations during the last years and created the development of new interspecific or even intergeneric hybrids
  - Examples we can find in Osteospermum, Lobelia, Impatiens, Nemesia, Calibrachoa …
- In ornamentals very often the new hybrid is the variety or the starting point of a completely new genepool
- Backcrossings to commercial varieties to transfer a single characteristic trait (like a desease resistance) have very little relevance in vegetative propagated bedding plants
- Due to this breeding method we find many varieties with a very limited fertility and complex genepools with a range of different ploidy levels

Conventional breeding approaches: Cut flowers

- Cut flower production has been moved over the last decades from Europe and North America to East Africa and South America due to lower production costs and better climate conditions
  - Shipping ability has become an important selection criteria
  - Suitability for sea freight may become a new challenge for the breeders
  - Productivity is also in the low costs countries a major breeding target
- Cut flower breeders have moved their activities to East Africa and South America
  - Trial Stations
  - Purchase of cut flower farms by breeding companies
  - Dislocation of complete breeding programs
- Major cut flower producers in Central America and East Africa have started themselves to invest into breeding

Conventional breeding approaches: Cut flowers



- The carnation breeding program of Selecta benefits from the assets of the different locations of the company and is adapted to the needs of the key markets
  - Genepool and candidate stock is kept in Germany
  - Crossing work is done in Tenerife
  - Seedling selection takes place in Kenya
  - Trials of the selected clones are in Germany, Kenya, Italy, Japan and Columbia
- Breeders need strong management skills and have to be prepared to travel

Genetic engineering in ornamentals

Examples 1987 to 2005

- Anthurium
- Antirrhinum
- Begonia
- Calendula
- Dendrathema
- Dedrobium
- Dianthus
- Eustoma
- Gentiana
- Gerbera
- Gladiolus
- Osteospermum
- Pelargonium
- Petunia
- Rhododendron
- Rosa
- Torenia

- Flower colour
- Fragrance
- Vase life
- Production characteristics
- Stress tolerance
- Pathogene resistance

TABLE 3

TRANSGENIC FLORICULTURE CROPS WITH MODIFIED TRAITS

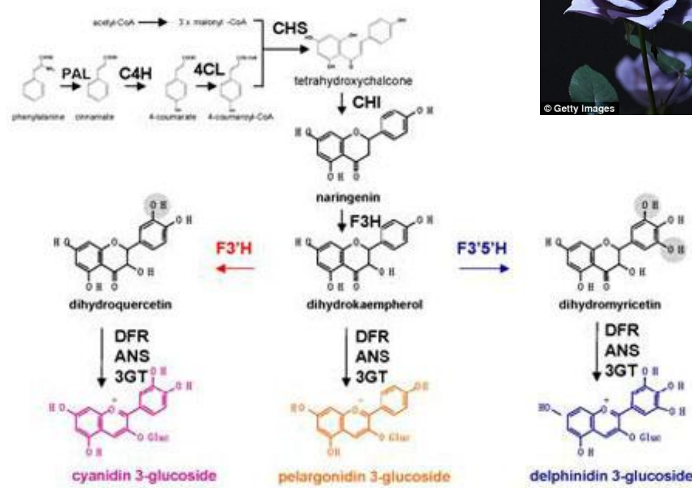
Species	Trait	Reference
Anthurium andraeanum	Delay in bacterial blight symptom development	Kuehnle et al., 1993
Antirrhinum majus	Altered phenotype (dwarfness, decreased apical dominance, increased flower number)	Handa, 1992
Begonia × cheimantha	Increased keeping quality	Hvoslef-Eide et al., 1995
B. tuberhybrida	Modified phenotype (dwarfness, delayed flowering, wrinkled leaves and petals)	Kiyokawa et al., 1996
B. semperflorens	Altered flower color	Scotts, 2003*
	Glyphosate tolerant	Scotts, 2003*
Calendula officinalis	Glyphosate resistant	Scotts, 2002, 2003*
Dendrathema grandiflora	Modified flower color (pink to pale pink, white)	Courtney-Gutterson et al., 1994
	Enhanced resistance to grey mold	Takatsu et al., 1999
	Improved resistance to tomato spotted wilt virus	Sherman et al., 1998b
	Modified plant architecture (shorter plant, larger branch angle)	Zheng et al., 2001
	Reduced plant height	Petty et al., 2003
	Modified phenotype (no branch)	Lee et al., 2003
	Modified phenotype (compact growth, increased number of axillary shoots)	Aswath et al., 2004
Dendrobium	Altered flower color, disease resistant	University of Hawaii, 1999*
Dianthus caryophyllus	Altered flower color (white to light mauve, mauve, violet)	Lu et al., 2003
	Increased vase life	Savin et al., 1995
	Altered flower color (pink to pale pink)	Gutterson, 1995
	Increased vase life	Bovy et al., 1999
	Improved fusarium wilt tolerance	Brugliera et al., 2000
	Flower color altered (orange to cream), increased fragrance in some transgenic plants	Zuker et al., 2002
	Improved tolerance to fusarium	Ahn et al., 2004b
Eustoma grandiflorum	Altered flower color (purple to white or pattern)	Deroles et al., 1995, 1998
	Altered flower color (purple to magenta)	Nielsen et al., 2002
Gentian triflora	Altered flower color (blue to pale blue, white)	Nishihara et al., 2003
Gerbera hybrida	Altered flower color (red to pale pink or cream)	Elomaa et al., 1993
	Altered flower color	Florigene Ltd, unpublished results
Gladiolus	Enhanced resistance to bean yellow mosaic virus	Kamo et al., 2002, 2005
Osteospermum	Modified ornamental traits	Giovannini et al., 1999
Pelargonium	Improved ornamental characters and fragrance production	Pellegrineschi et al., 1994
	Botrytis cinerea resistant, extended flower life	Sanford Scientific, 1997*
	Botrytis cinerea resistant	Bi et al., 1999
	Glyphosate tolerant	Scotts, 2000*
	Altered flower color	Scotts, 2001*
	Dwarf phenotype	Boase et al., 2004
Petunia hybrida	Altered flower color (white to red and pattern)	Meyer et al., 1987
	Altered flower color (purple to white and pattern)	van der Krol et al., 1988, 1990
	Altered flower color (white to red)	Bradley et al., 1995
	Disease resistant	Sanford Scientific, 1996*
	Extended flower life	Monsanto, 1997*
	Altered leaf, stem and sepal color (green to dark purple)	Bradley et al., 1998
	Altered flower color (white to pale yellow, deep purple to pale purple)	Davies et al., 1998
	Early flowering	Baker et al., 2002
	Extended flower life	Shaw et al., 2002
	Extended flower life	Smith et al., 2002
	Extended flower life	Chang et al., 2003
	Altered flower color (white to pink)	Davies et al., 2003
	Glyphosate tolerant	Scotts, 2003*
	Altered flower color (red to deep red with deep purple sectors)	Mori et al., 2004
	Altered flower color	Scotts, 2004*
	Altered flower color (purple to almost white, red; red to orange; violet to pale violet)	Tsuda et al., 2004
	Cold tolerant, drought tolerance, increased salt tolerance	University of Florida, 2005*
Rhododendron	Phytophthora resistant	University of Connecticut, 2000*, 2004*
Rosa hybrida	Altered flower color (red to pink)	Gutterson, 1995
	Altered flower color (red to light red, magenta red), modified plant habit	Soug et al., 1996
	Improved rooting characteristics	van der Salm et al., 1997
	Reduced blackspot disease	Marchant et al., 1998b
	Enhanced resistance to powdery mildew	Li et al., 2003
	Altered flower color	Florigene Ltd and Suntory Ltd, unpublished results
Torenia fourieri	Altered flower color (blue to blue/white, white)	Suzuki et al., 1997
	Altered flower color (violet, reddish-purple to lighter color)	Aida et al., 2000
	Extended flower life, increased flower number	Aida et al., 1998
Torenia hybrida	Altered flower color (blue to blue/white, white)	Suzuki et al., 2000
	Altered flower color (blue to pink, more red, pale blue)	Suzuki et al., 2002

* From the field test release permits database for the US (http://www.isb.vt.edu/cfdocs/fieldtests3.cfm).

aus : Chandler & Lu (2005) In vitro Cellular & Developmental Biology 41 (5):591-601

Genetic engineering in ornamentals

- Commercial examples



Biotechnology in ornamentals: Genetic engeneering

- Breeding companies today have very limited activities in the field of genetic engineering
  - Small markets even of the most important ornamentals
  - High deregulation costs
  - Lack of access to intellectual property rights of enabling technology and interesting trait genes
  - High costs for research and development
  - Fundamental opposition against GMO's in Europe

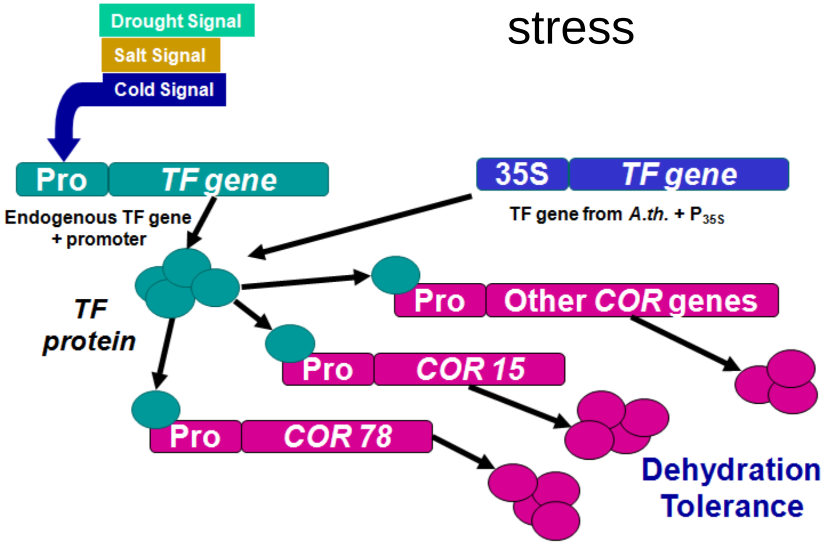
Biotechnology in ornamentals: Genetic engeneering

ornamental bioscience

- Ornamental Bioscience was founded in 2007 as a joint venture of Mendel Biotechnology and Selecta Klemm
  - Mendel Biotechnology has characterized transcription factors from Arabidopsis
  - Transcription factors which give increased abiotic stress tolerance and disease resistance are tested in ornamentals
  - Ornamental bioscience has access to the enabling technology of Monsanto
- The vision is to create a new generation of convenience plants which are easy to handle,stay healthy and are tolerant to reduced water supplies

Genetic engineering of ornamentals

- First results of Ornamental Bioscience
  - Improvements in Petunia:
    - Reduction of the water demand of 30 %
    - Tolerance against long drought periods
    - Normal plant development also after several periods of drought stress



Biotechnology in ornamentals: Marker technology

- Molecular markets have been applied in a huge amount of species (160 before 2006)
- Fast majority of applications in ornamentals is in the field of fingerprinting research for identification, diversity and taxonomy studies
- The history of the gene pool of ornamentals is very often unknown in ornamentals. Fingerprints are a powerful technology to get an understanding of the relationship between different genotypes and to make the start of a new breeding program more effective.

Biotechnology in ornamentals: Marker technology

- Marker assisted selection is still - with a very few exceptions - not used in ornamental
- One reason is that the research applied before marker assisted selection is long term and costly
  - Exact phenotyping
  - Clarification of the inheritance of important traits
  - Genetic linkage maps
- Ornamentals have very often a complex cytology which increases the complexity
- Roses are the best studied groups in ormamnetals. A linkage map is available and disease resistance genes have been chracterized. Nevertheless to my knowledge the markers are not used in the commercial breeding programms
- Before marker technology will be applied in breeding programms much more research has to be done. A development as we have seen it in the breeding of vegetables is very unlikely.

Double flowering Calibrachoa: A case study

- The breeding program was established in 1996 with the focus on colour, production characteristics and early flowering
- In the 2006/2007 the first variety with double flowers was introduced by Selecta and recognized as a major step in the Calibrachoa breeding
- In the US a Utility patent was filed and granted with the title "Double Flowering Calibrachoa Breeding Methods and Plants Produced Therefrom"
- In the breeding process of the Double Flowering Calibrachoa new technologies had to be developed or adapted for this species and contributed to the development of the new trait
  - Protoplast culture
  - Induction of mutations
  - Anther culture

Double flowering Calibrachoa: A case study

- Beside the implementation of the technology a new species was integrated into the breeding program
- Already in 2008 a competitor presented on the US Pack trials a Calibrachoa variety with double flowers
- AFLP and cytology analysis proved that the variety was a hybrid of the first commercial variety
- It took years and a highly sophisticated breeding approach to develop this new character in Calibrachoa
- Unfortunately due to the relatively simple inheritance of the double flowering it can be tranferred very easily to new varieties

Intellectual property rights and breeding progress

- Effective Plant Breeder Rights are a precondition for the commercial breeding of vegetatively propagated ornamentals
- The UPOV convention from 1991 has improved the position of the breeders
  - Vast majority of the growers accept that mutations belong to the breeder of the original variety
- Illegal propagation is still a severe problem and breeders have to defend their position constantly
- We have today more conflicts between the breeders in the field of EDV‘s and patents
- Patents can be an important addition to plant breeders rights for the breeders of ornamentals

Thank you for your attention !

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