Breeding prospects for horticulture in Asia

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Introduction

1. Proprietary seed market accounts for almost 67% (Watch, 2009)
2. Horticultural seed companies are minor in world seed trade.
3. Only Sakata and Takii are Asian seed companies ranked in world top 10 seed company. Both occupy only 2% of world seed market. → Seed companies based in Asia are still weak
4. Sakata and Takii are both strong in world flower seed market.
5. Zespri and Suntory, originated in Asia, are very strong world-wide in specific fields, eg) Kiwii and flower breeding
6. Crop oriented private company or governmental institutes are focusing on breeding and development of specific crops.

Horticultural seed market in Asia

Table 4. Horticultural Seed market in Asian countries.

Countries	Market size(million US$)
China	4,000
India	1,500
Japan	1,500
Russia	500
Australia	400
Republic of Korea	400
Other	300
Total	**8,600**

Horticultural seed market in Asia

- Vegetables : Chinese cabbage, Radish, Watermelon, Strawberry,
- Fruit trees : Kiwii fruit, Apple, Pears, Grape,
- Ornamental flowers : Lisianthus, Gentiana, Statice, Pansy, Petunia, seed Lilium
- Companies :
  - Vegetables : Sakata, Takii, Nongyu, Nongwoo, Individual breeders etc.
  - Fruit trees : Governmental institute, Zespri int'l, individual breeders etc.
  - Flowers : Sakata, Takii, Myoshi, Suntory, Florigene etc.

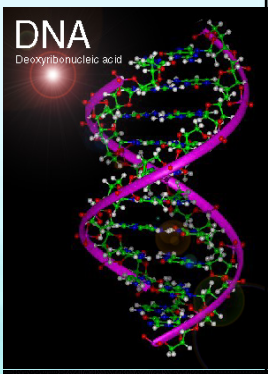
Recent breeding activities for horticultural crops in Asia

Breeding tools ?

Gene / Chromosome manipulation

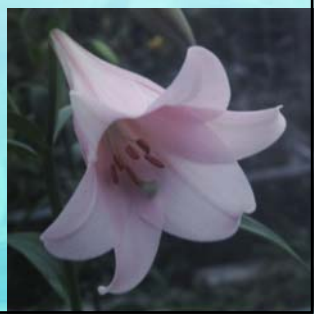
- **+, – : Crossing**
- **+ : GMO**
- **– : Mutation**
- X **: Polyploidisation (2x → 4x → 8x)**
- ÷ **: Haploidisation (2x → x)**

Plant breeding is the purposeful **manipulation** of plant species in order to create desired genotypes and phenotypes for specific purposes



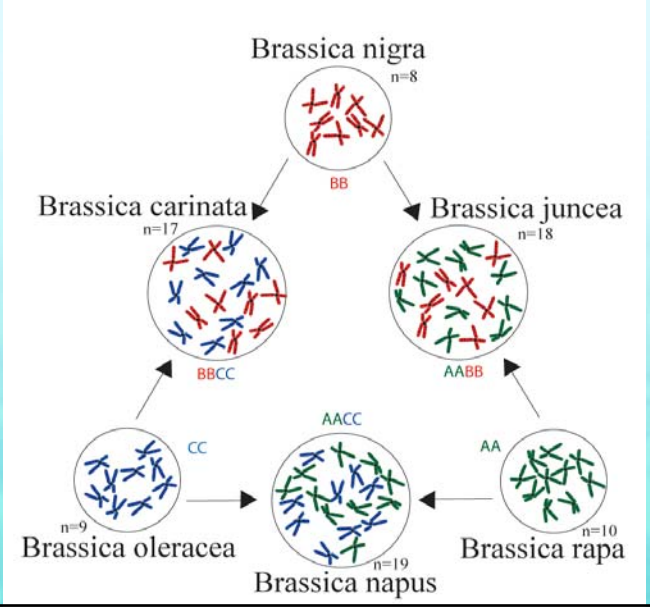
Tools for improving crop quality

1. Hybrid Breeding : SI, MS, haploid breeding, intra- or interspecific hybridisation : all crops
2. Mutation Breeding : ornamental flowers, cereals
3. GMO Breeding : ornamental flowers
4. Marker Assisted Breeding : vegetables, fruit trees



Interspecific hybridization

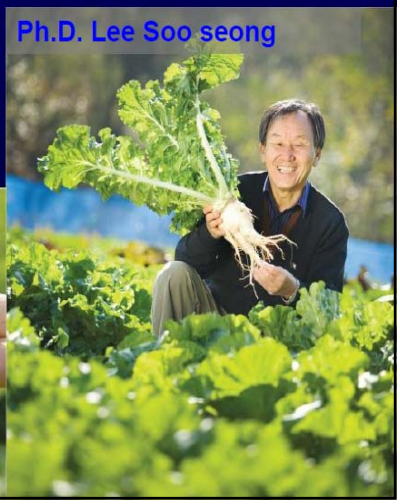
Interspecific hybridization in *Brassica* revealed by U(1935)



Sparkling breeders

Brassica campestris X Raphanus satives

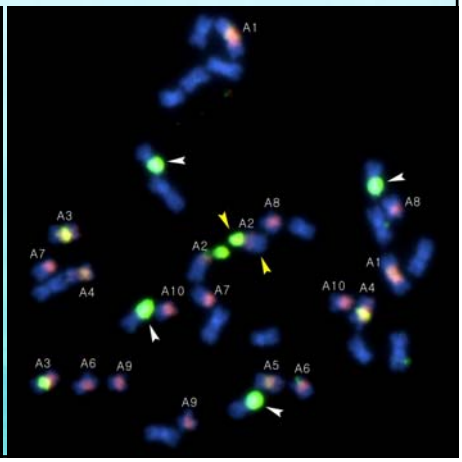
“ Sulforaphene ” contents ↑



Chinese cabbage (♀) × Korean radish (♂)
↓ ← ovule culture
OV115
↓ ← colchicine treatment
OV115C
↓ ← anther culture
OA20-1-10-1
↓ ← microspore culture
OAM1-2

Brassicoraphanus

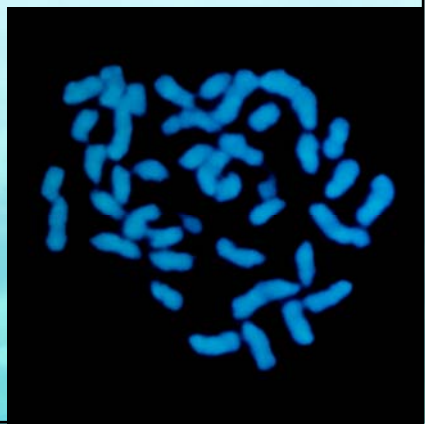
2n=4x=37
A genome =19 (instead of 20)
C genome =18



A new type of *Brassica napus* for leafy vegetables

B. rapa(**A**, 2n=20) **x** *B. oleracea*(**C**, 2n=18) → several times BC to *B. rapa* → 2n=2x=25, 26 → Selfing → F3-F4 (2n=4x=38+2), infertile

Korean "Ssamchu"



Super-sweet Oriental melon 'GumSsaraki'

W. Russian melon (monoecious) X Golden O. melon → F_1 → BC_2 X Korean melon → Monocious line

W. Russian melon X Golden O. melon → F_1 → BC_3 X Melon → Super sweet dioecious line

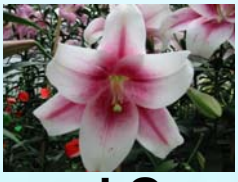
17years' breeding

Gumssaraki

Factors affecting interspecific hybridization in lily

- Pre-fertilization barrier; inability of pollen grains to germinate on the stigma
  - Mentor pollination
  - Bud pollination
  - Cut-style
  - Grafted-style
- Post-fertilization barrier; abortion of embryo and endosperm
  - Ovary culture
  - Ovule culture
  - Embryo culture

Simplified crossing polygon genus *Lilium*



Lilium longiflorum

LO

Oriental hybrids

L. auratum
L. speciosum
L. rubellum

LA

OA

Asiatic hybrids

L. tigrinum
L. bulbiferum
L. maculatum
L. dauricum
L. davidii

Interspecific hybridization in lily

Embryo culture

Sporads in F1 interspecific hybrid

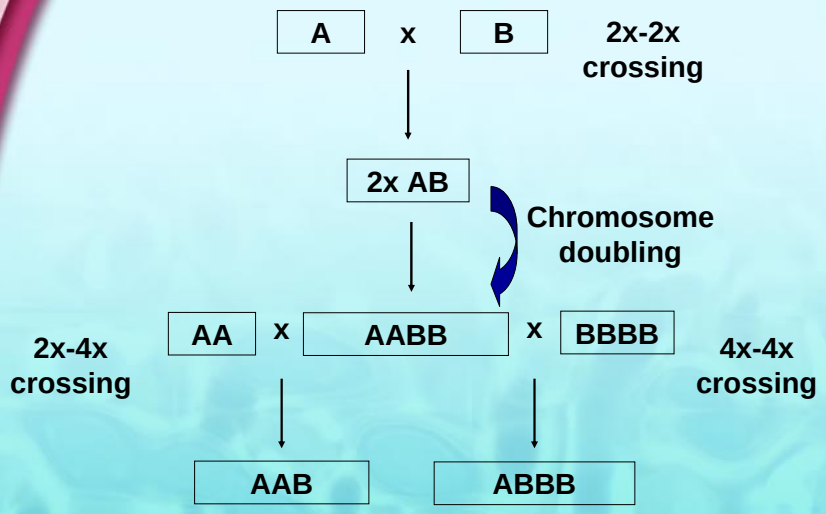
- **Tetrad - result from reductional and equational division.**
  1 PMC --> 4 x n-gamete.

- **Triad - result from reductional division and restituted only one part by SDR.**
  1 x 2n-gamete and 2 x n-gamete

- **Dyad - result from FDR or SDR or IMR**
  2 x 2n-gamete.

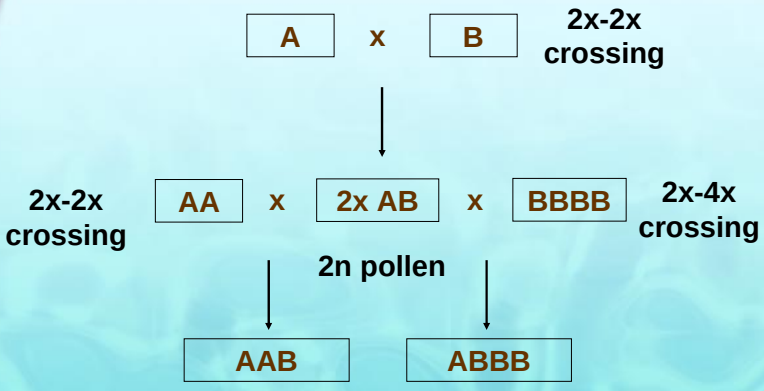
- **Monad - result from double restitution via both FDR and SDR.**
  1 x 4n-gamete.

Interspecific hybridization 1



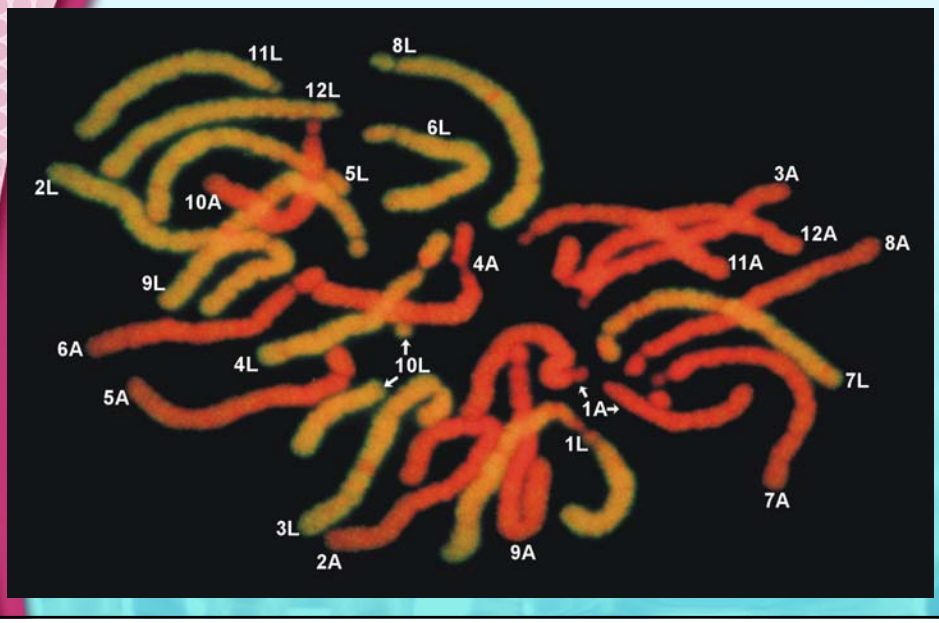
Color variation from 2x-gametes of F1 hybrid

Interspecific hybridization 2



Color variation from 2n-gametes of F1 hybrid

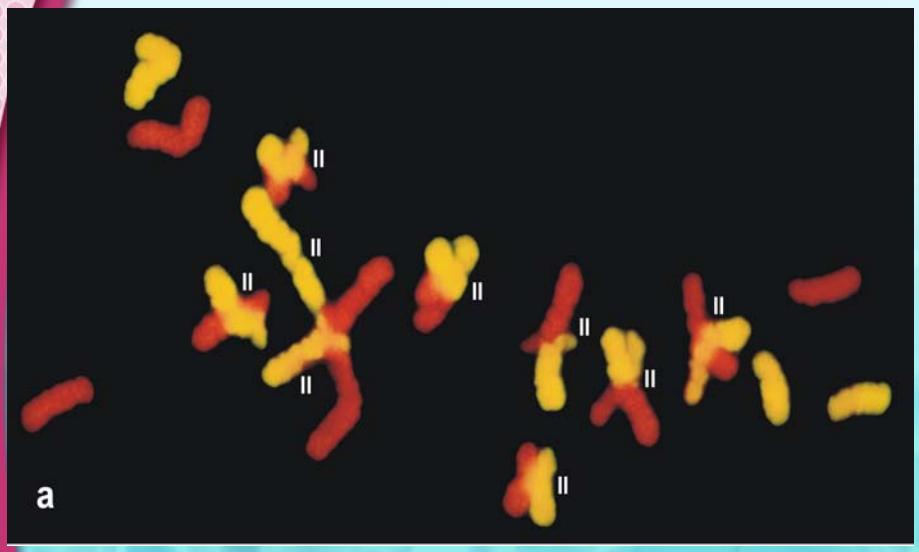
Mitotic metaphase chromosome of LA hybrid (F1)



How to overcome F_1 sterility?

- By mitotic polyploidization
  - Somatic chromosome doubling
  - Colchicine or Oryzalin
  - No homoeologous recombination
- By meiotic polyploidization
  - 2n-gametes by FDR, SDR and IMR
  - Homoeologous recombinations

Meiotic metaphase I stage of LA hybrid (F_1)



BC_1 hybrid : 2n=3x=36= 12 A x (12 L + 12 A)

Mitotic chromosomes (BC2)

Mutation breeding

Plant Breeding using the ion beam irradiation

- RIBF is the biggest facilities capable of accelerating heavy ions world wide
- Ion beam is highly effective for inducing mutagenesis of tobacco embryos during fertilization without damage to other plant tissue. Eg) albino, periclinal chimera, sectorial chimera, herbicide-tolerant and salt-tolerant phenotypes
- 6 new flower cultivars on the market in Japan, USA, Canada and EU since 2002 by RIKEN: only three years breeding period
- The ion beam irradiation technique induces a high mutation rate without severe growth inhibition at relatively low doses.

Variety development by radiation breeding methods by countries in 2009

Crops	**China**	**India**	**Japan**	**Russia**	**Korea**	Netherlands	Germany	USA
Major cereals	366(55.9)	58(21.4)	82(35.2)	41(19.4)	8 (42.1)	1 (0.6)	72(41.6)	39(31.2)
Soybean	56 (8.5)	39 (14.1)	25 (10.7)	28 (13.3)	2 (10.5	-	10 (5.8)	26 (20.8)
Minor cereals	70 (10.7)	9 (3.3)	4 (1.7)	62 (29.4)	-	-	-	12 (9.6)
Industrial crops	23 (3.5)	29 (10.5)	9 (7.5)	10 (4.7)	-	-	-	3 (2.4)
Oil	41 (6.3)	16 (5.8)	1 (0.8)	3 (1.4)	6(31.6)	-	-	1(0.8)
Flowers	**60 (9.2)**	**95 (34.4)**	**81(34.8)**	**40(19.0)**	**2 (8.0)**	173(98.3)	80(46.2)	23(18.4)
Fruit tree	**20 (3.1)**	**2 (0.7)**	**6 (2.6)**	**7 (3.3)**	-	-	-	2 (1.6)
Vegetables	**17 (2.6)**	**14 (5.1)**	**14 (6.0)**	**10 (4.7)**	-	2 (1.1)	1 (0.6)	3 (2.4)
Others	2(0.3)	14 (5.1)	11 (4.7)	10 (4.7)	-		10 (5.8)	16(12.8)
Total	655(100%)	276(100%)	233(100%)	214(100%)	19(100%)	176(100%)	173(100%)	125(100%)

(FAO-IAEA MVD, 2009)

Mutant lines developed in various crops using RIBF

Mutant phenotype	Plant material	Ion/Dose (Gy)	Survival/ Mutation (%)	Developer
Sterile				
Verbena	Stem	N/10	842.8	Suntory Flowers Ltd
Cyclamen	Tuber	C/12	50/13	Hokko Chem, Ind. Co Ltd
Flower color and shape				
Dahlia	Shoot	N/5	NE/20.3	Hiroshima City Agri Forest Prom, Cen.
Rose	Dormant scion	Ne/15	70/51.7	Kanagawa
		N/30	90/43.1	Pref Agri Cent
Chrysanth.	Stem	C/10	94/14	Plt Btech. Inst. Ibaraki Agri, Cen.
Torenia	Leaf/stem	N/50	NE/1.9	
		Ne/20	NE/1.6	
Variegation				
Petunia	Stem	N/5	ND	Suntory Flowers Ltd
Sweet pepper	Dry seed	Ne/10	80/1.3	Natl. Inst. Veget. and Tea Sci.

ND: no data, NE: no effect

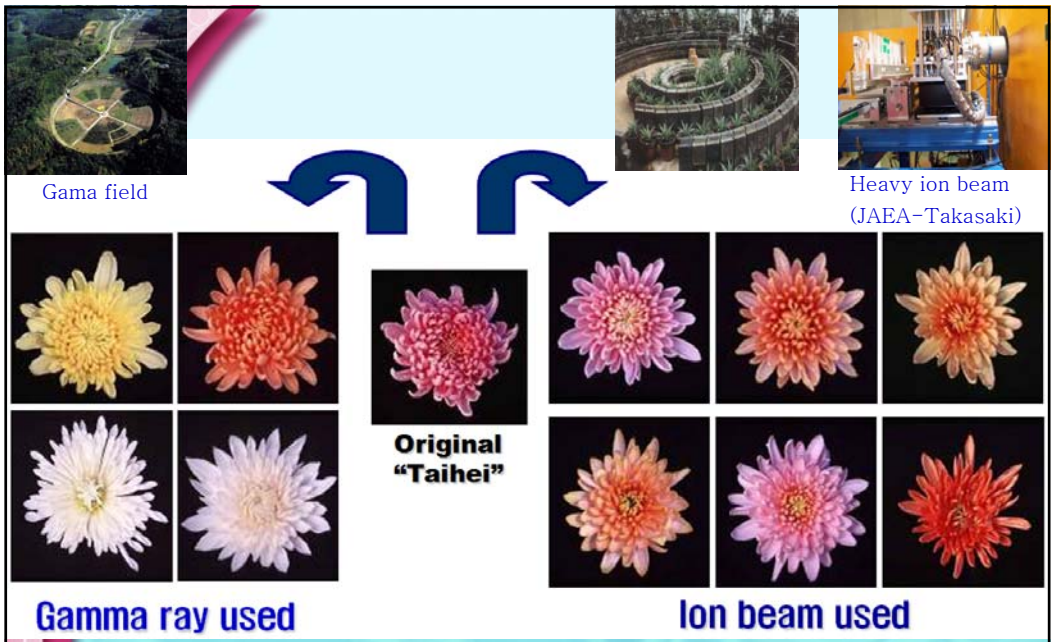
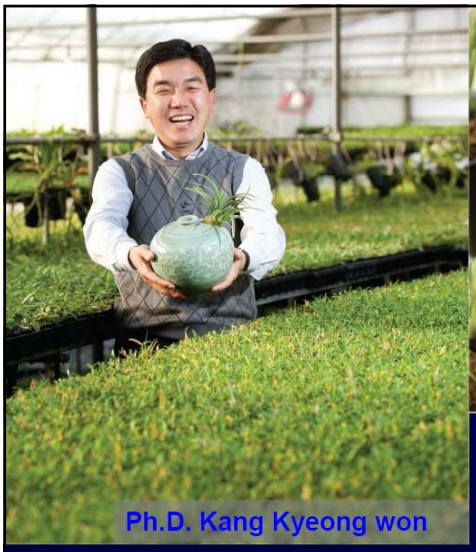


Fig. 7. Examples of mutation breeding in Japan. Flower color modification in chrysanthemum often showed by irradiation of gamma ray and ion beam. Ion beam irradiation showed higher frequency in flower color changes.



Cymbidium , Aerides etc.

- Breeding by crossing
- Radiation breeding

Orchid breeding by radiation

Calanthe striata
'Shinlock'

C. striata **'Saebyuk'**

Orchid breeding by radiation

Dendrobium kingianum 'Royal gold'

D. monifolium 'Royal present'

Director general of IAEA with Oriental orchid mutant

- Application of radiation breeding in Orchids in Korea
- Chronic and acute irradiation of gamma ray on in vitro rhizome and seed of Oriental *Cymbidium* : Fragrance, cold resistance, dwarfism, resistant to climate
- Multiplication of mutant lines and commercialization : export to Japan, and other countries
- Inducing mutation of Orchids seeds via space radiation in 2008.

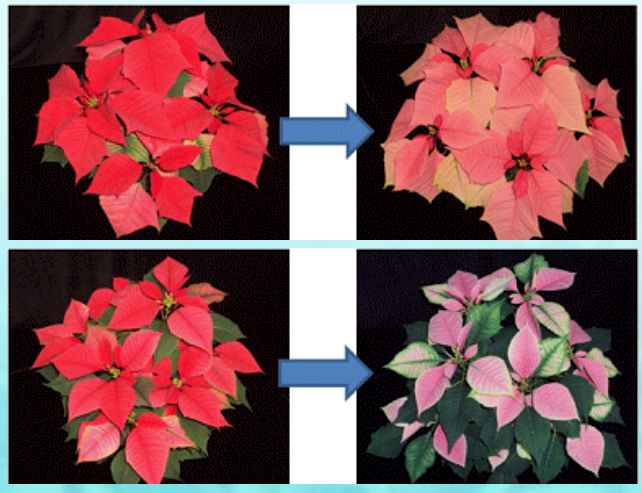
Variegated leaves of *Dendrobium* Orchids from seeds carried on the China spaceship 'Shenzhou #8(2009.9)

Control

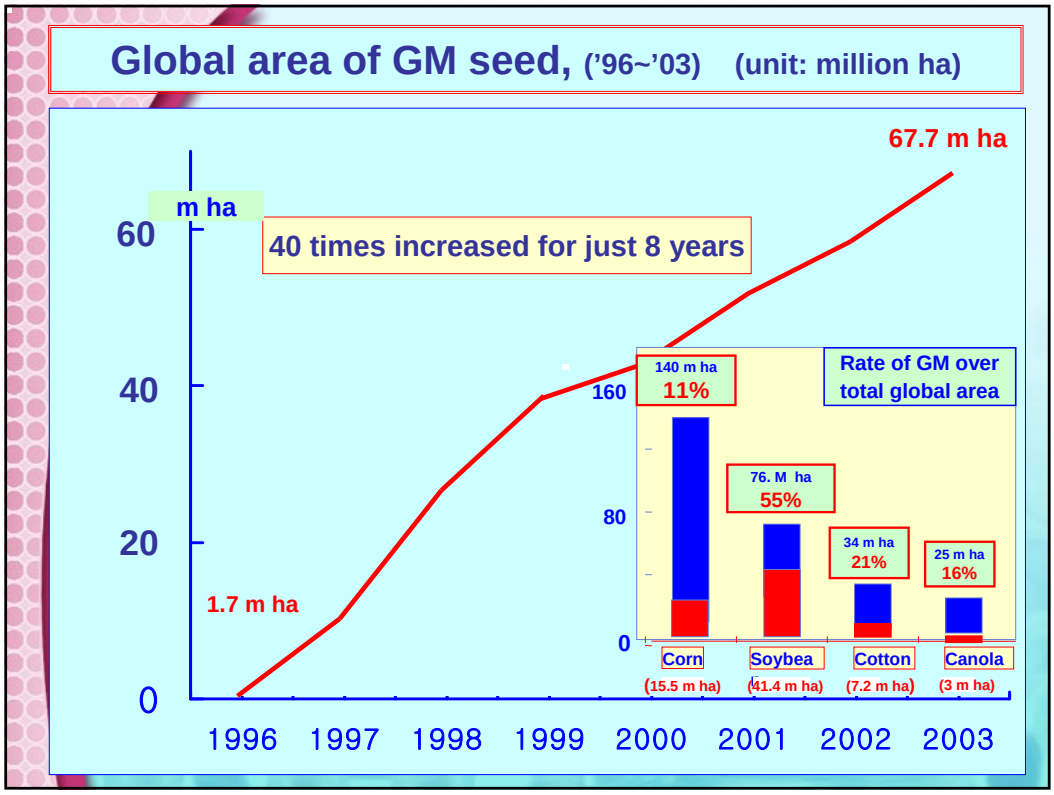
Foggy leaves

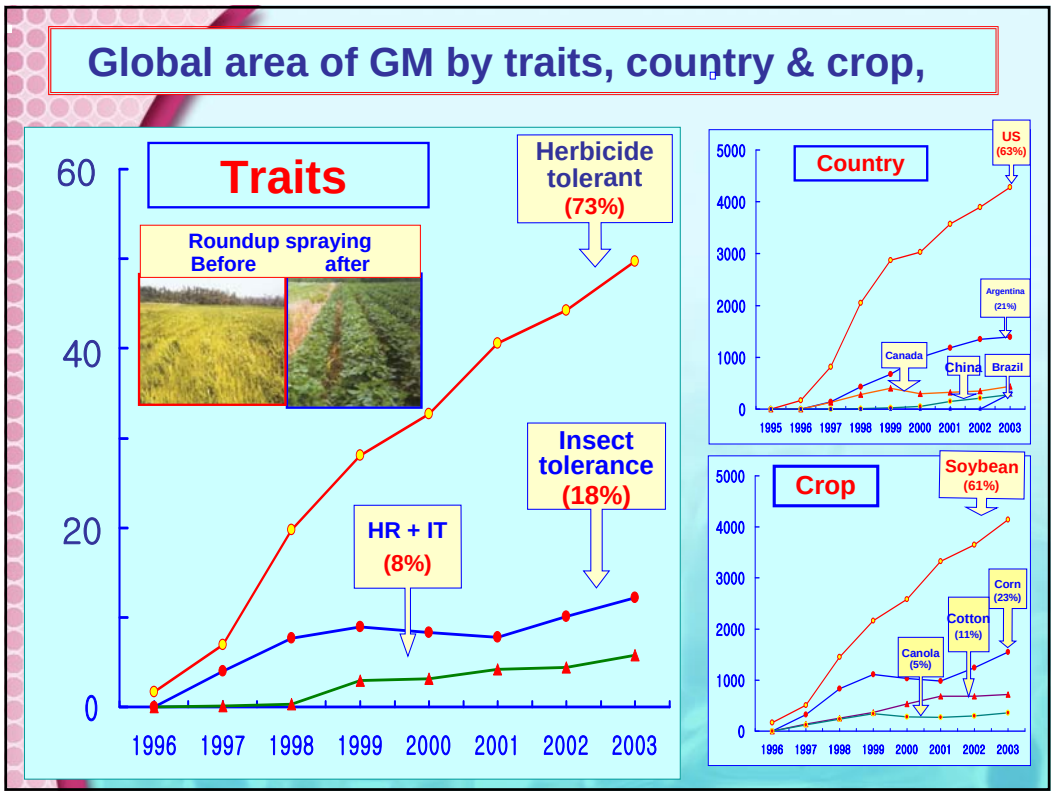
Yellow centered leaves

Poinsettia breeding by radiation



Genetic engineering


Global area of GM seed, ('96~'03) (unit: million ha)
67.7 m ha
m ha
60
40
20
0
40 times increased for just 8 years
1.7 m ha
1996 1997 1998 1999 2000 2001 2002 2003
Rate of GM over total global area
140 m ha
11%
76. M ha
55%
34 m ha
21%
25 m ha
16%
160
80
0
Corn
(15.5 m ha)
Soybea
(41.4 m ha)
Cotton
(7.2 m ha)
Canola
(3 m ha)

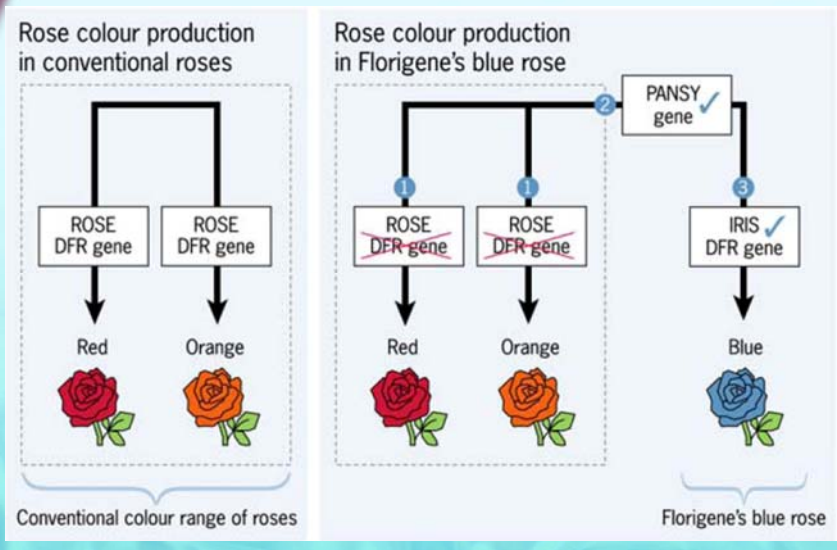

Global area of GM by traits, country & crop,
Traits
60
40
20
0
Herbicide tolerant (73%)
Roundup spraying
Before
after
Insect tolerance (18%)
HR + IT (8%)
1996 1997 1998 1999 2000 2001 2002 2003
Country
5000
4000
3000
2000
1000
0
US (63%)
Argentina (21%)
Canada
China
Brazil
1995 1996 1997 1998 1999 2000 2001 2002 2003
Crop
Soybean (61%)
Corn (23%)
Cotton (11%)
Canola (5%)
1996 1997 1998 1999 2000 2001 2002 2003

Florigene - The World's First Molecular Breeder

Florigene, part of the Suntory Group, has used genetic modification technology to create valuable improvements to important flower species

"Applause" a blue rose cultivar bred first time through plant biotechnology in Japan.

Blue rose, a breakthrough in flower breeding by genetic engineering



Process of noble blue roses originated by plant biotechnology techniques by silencing red pigments "DFR" genes(figure originated from CSIRO).

Future prospects for horticulture breeding in Asia

For every ...

8,000 pints of beer

1,150 loaves of bread

600 kg of sugar

...£1 in royalty is reinvested in plant breeding.

For every...

150 stems of rose

200 stems of chrysanthemum

40 kg of strawberry

…$1 in royalty is reinvested in plant breeding.

Will it be possible?

Rainbow roses……

Will it be possible? It is already made!

Thank you for all your attention!