Breeding prospects for horticulture in Asia

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Contents

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
Korea	400
Other	300
Total	**8,600**

Horticultural seed market in Asia

- Vegetables : Hot Pepper, Chinese cabbage, Radish, Watermelon, Strawberry, Tomato, Onion
- Fruit trees : Kiwii fruit, Apple, Pears, Grape,
- Ornamental flowers : Lisianthus, Gentiana, Statice, Pansy, Petunia, seed Lilium
- Seed companies :
  - Vegetables : Sakata, Takii, Nongyu, Nongwoo etc.
  - Fruit trees : Zespri int'l, Governmental institute etc.
  - Flowers : Sakata, Takii, Myoshi, Suntory, Kirin etc.

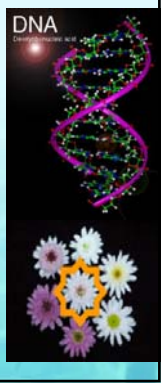
Recent breeding activities for horticultural crops in Asia

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, Fruit, cereals
3. GMO Breeding : ornamental flowers
4. Marker Assisted Breeding : vegetables, fruit trees

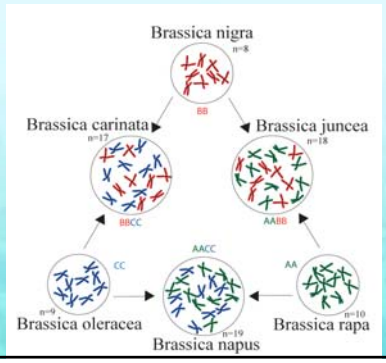
Pepper breeding in Asia

80 million $ market
China, India, Indonesia, Korea etc

Pepper breeding in Asia

Interspecific hybridization

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

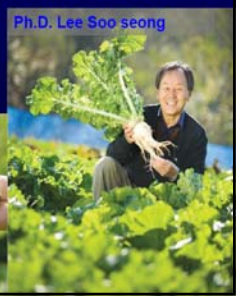


Sparkling breeders

Brassica campestris X Raphanus satives

" Sulforaphene " contents ↑

Ph.D. Lee Soo seong



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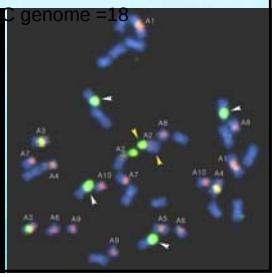
Chinese cabbage (♀) × Korean radish (♂)
↓ ← ovule culture
OV115
↓ ← colchicine treatment
OV115C
↓ ← anther culture
OA20-1-10-1
↓ ← microspore culture
OAM1-2

Brassicoraphanus

2n=4x=37

A genome =19 (instead of 20)

C genome =18



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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"

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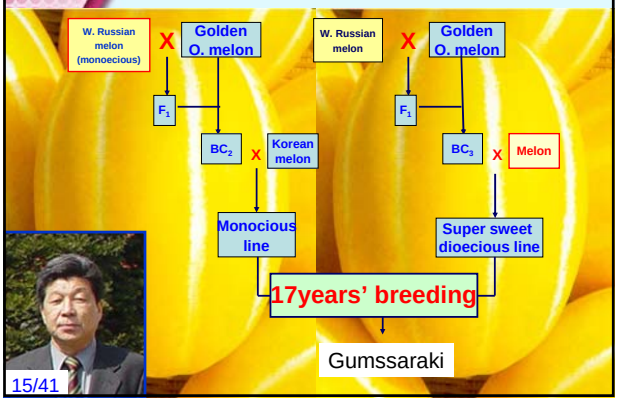
Super-sweet Oriental melon 'GumSsaraki'



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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

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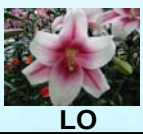
Simplified crossing polygon genus *Lilium*



Lilium longiflorum

LO

Oriental hybrids

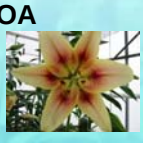
L. auratum
L. speciosum
L. rubellum

LA

OA

Asiatic hybrids

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



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Interspecific hybridization in lily

Embryo culture

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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

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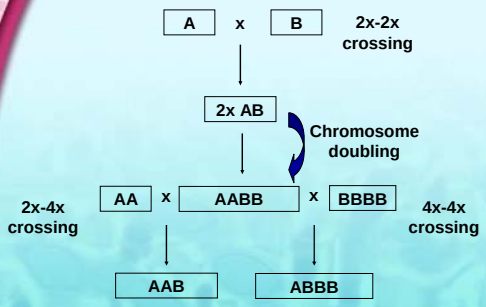
Interspecific hybridization 1: Mitotic polyploidization



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Color variation from 2x-gametes of F1 hybrid

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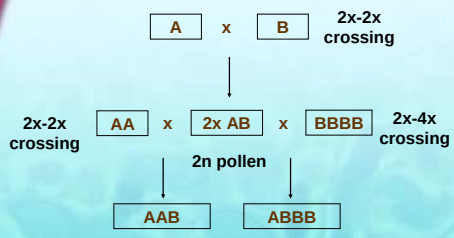
Interspecific hybridization 2: Meiotic polyploidization



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Color variation from 2n-gametes of F1 hybrid

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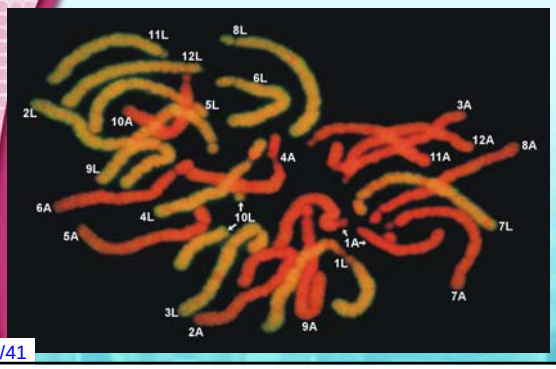
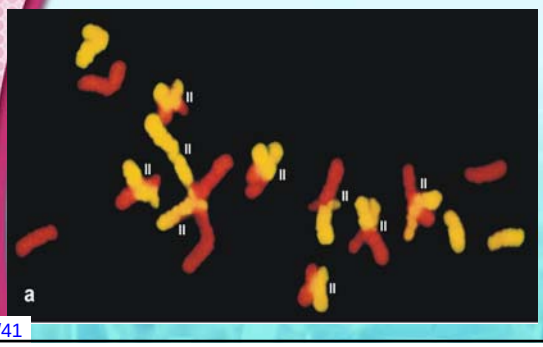
Mitotic metaphase chromosome of LA hybrid (F1)



Meiotic metaphase I stage of LA hybrid (F_1)



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

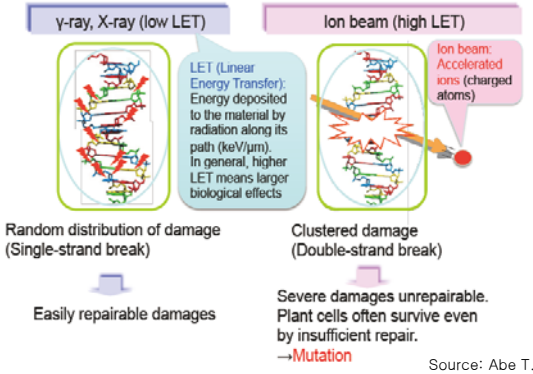
Mutation breeding

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)

Plant Breeding using ion-beam irradiation



Flower Mutants developed from the RIKEN beam

Mutant phenotype	Plant material	Mutation rate (%)
Sterile		
Verbena [1]	Stem	1.0-2.8
Cyclamen [2]	Tuber	6.7
Color and shape		
Petunia [3]	Ovary	1.0
Dahlia [4, 4]	shoot	20.3-50.1
Rose [5, 5]	Dormant scion	51.7-65.5
Chrysanthemum [6]	Stem	4.5-25.0
Torenia [7,8]	Leaf and stem	1.9-17.1
Orchid [9]	shoot	5.0-6.3
Variegation		
Petunia Hybrida [9]	Stem	1.8
Dwarf		
Tricyrtis hirta [9,10]	Embryogenic callus	10.8

Advantages of ion-beam breeding
- Low dose, high mutation rates, and wide variation.
- Simple process to select new cultivars within a short time.

1) Kanaya et.al. Plant Biotec. 25, 91-96 (2008)
2) Sugiyama M. et.al., Plant Biotec. 25, 101-104 (2008)
3) Suzuki K. et.al., RIKEN Accel. Prog. Rep. 32, 146 (1999)
4) Hamatani M. et.al., RIKEN Accel. Prog. Rep. 34, 169-170 (2001)
5) Hara Y. et.al., RIKEN Accel. Prog. Rep. 36, 135 (2003)
6) Suzuki K. et.al., RIKEN Accel. Prog. Rep. 38, 138 (2005)
7) Miyazaki K. et.al., Plant Biotec. 23, 163-167 (2006)
8) Sasaki. et.al., Plant Biotec. 25, 81-89 (2008)
9) Miyazaki K. et.al., RIKEN Accel. Prog. Rep. 35, 130 (2002)
10) Nakano M. et.al., Plant Biotec. 27, 155-160 (2010)

30/41 Source: Abe T.

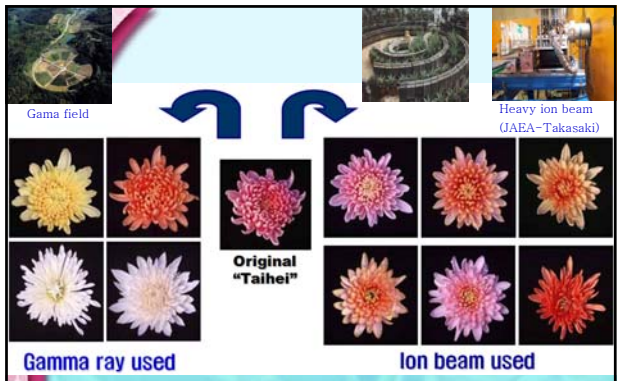


Fig. 7. Examples of mutation breeding in Japan. Flower color modification in chrysanthemum often showed by irradiation of gamma ray and ion beam. Ion beam irradiation showed higher frequency in flower color changes.

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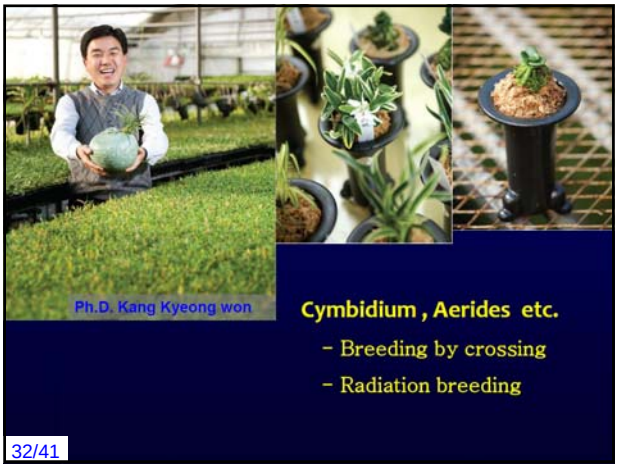

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Orchid breeding by radiation

Calanthe striata 'Shinlock'

C. striata 'Saebyuk'

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Orchid breeding by radiation

Dendrobium kinglanum '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.

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

Control | Foggy leaves | Yellow centered leaves

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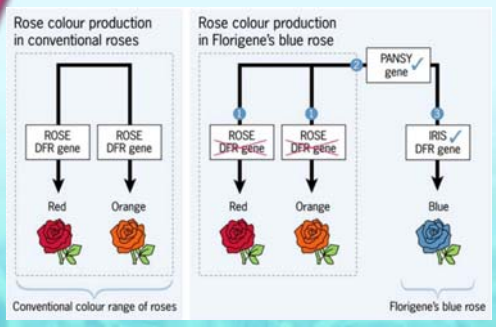
Genetic engineering

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 your attention!