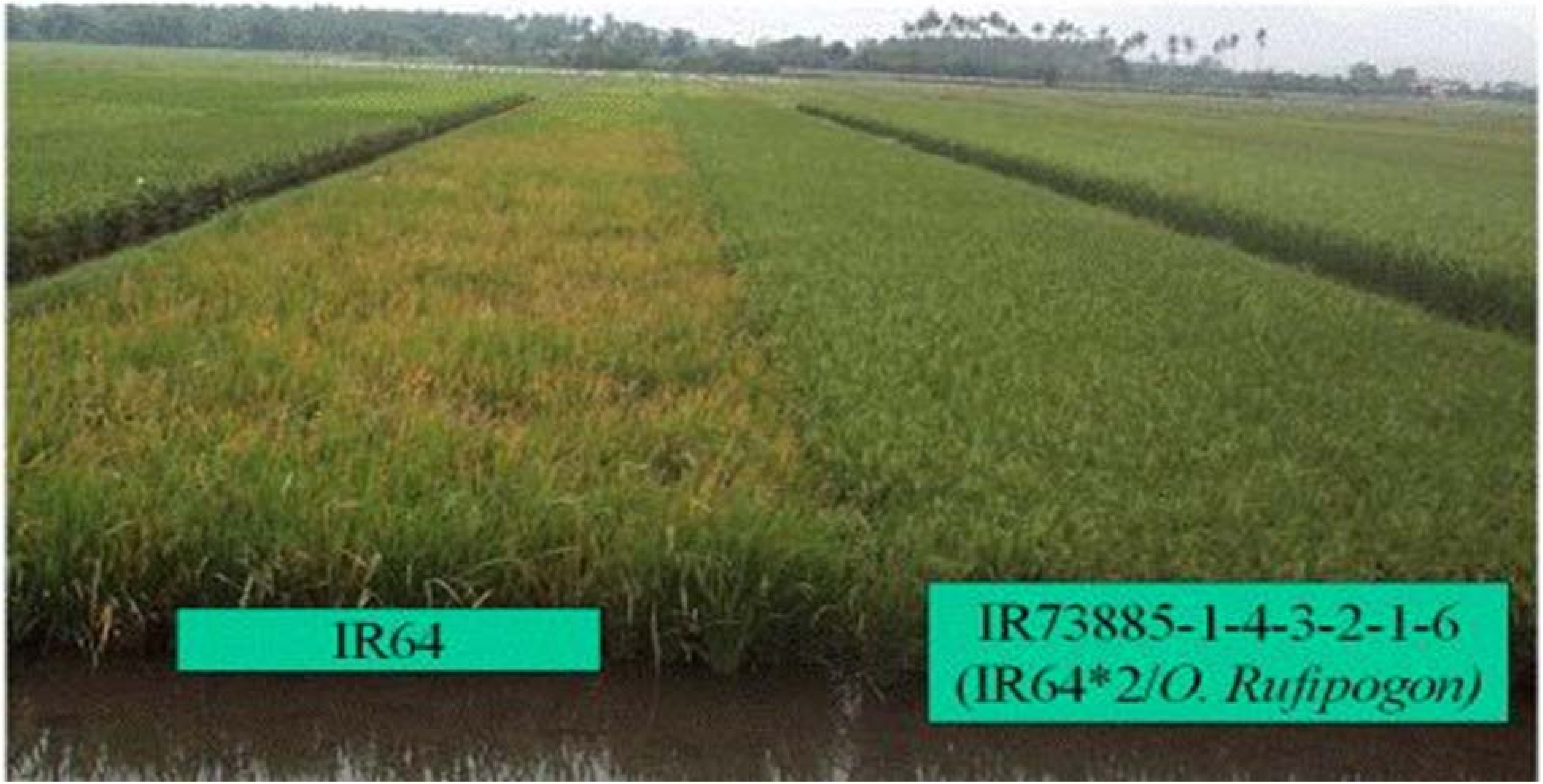
Backcross Breeding

- **The hybrid and the progenies in the subsequent generations are repeatedly backcrossed to one of the original parents used in the cross**
- **The objective of backcrosses method is to improve one or two specific defects of a high yielding variety**
- **Recently, tungro resistance has been transferred from *O. rufipogon* by recurrent backcrossing to IR64.**

Backcross Breeding

- **Usually associated with improving cultivar of self-pollinated species or an _inbred_ of a cross-pollinating species for trait governed by single gene**
- **Provides precise way of improving a cultivar that excels in a large number of attributes, but is deficient in one characteristic**
- **Provides gains of predictable value from improved trait.**

Backcross Breeding



Backcross Breeding

(A = recurrent parent, B = non-recurrent, donor parent)

- **step 1: cross (A x B) → F1 (50% recurrent parent)**
  - [50% of genome from A plus 50% of unrelated genome from B]
- **step 2: backcross (A x F1)→BC1F1 (75% recurrent parent)**
  - [50% of genome from A plus 50% of genome from F1, which itself is 50% A]
  - therefore [50% + 50%(50%)] = 75% A genome
- **step 3: backcross (A x BC1F1)→BC2F1 (87.5% recurrent parent)**
  - [50% of genome from A plus, 50% of genome from F1, which itself is 75% A]
  - therefore [50% + 50%(75%)] = 87.5% A genome

Backcross Breeding

- **step 4: backcross (A x BC2F1)→BC3F1 (93.75% recurrent parent)**
  - **[50% of genome from A plus 50% of genome from F1, which itself is 87.5% A]**
  - **therefore [50% + 50%(87.5%)] = 93.75% A genome**

- **step 5: backcross (A x BC3F1)→BC4F1 (96.875% recurrent parent)**
  - **[50% of genome from A plus 50% of genome from F1, which itself is 93.75% A]**
  - **therefore [50% + 50%(93.75%)] = 96.875% A genome**

Backcross Breeding

- **General equation for average recovery of the recurrent parent : $1 - (\frac{1}{2})^{n+1}$**
- **where, n is the number of backcrosses to the recurrent parent**

  for the F_1, n= 0;

  for BC_1, n=1;

  for the BC_2, n=2;

  for the BC_3, n=3, etc.

Implementation

- **Satisfactory recurrent parent must exist. Backcross procedure produces new cultivar phenotypically similar to one favored by both farmer and processor.**
- **Must still be satisfactory for all traits, (other than the one to be improved), in 6-10 generations down the road.**
- **Commonly used to transfer disease resistance genes, eg powdery mildew and leaf rust in wheat, phytophthora resistance in soybean.**
- **Growing demand for food and processor quality traits, breeders see resurgence in backcrossing compositional traits such as fatty acid and amino acid composition traits to specific lines of interest in soybean, corn, canola, and other crop species.**

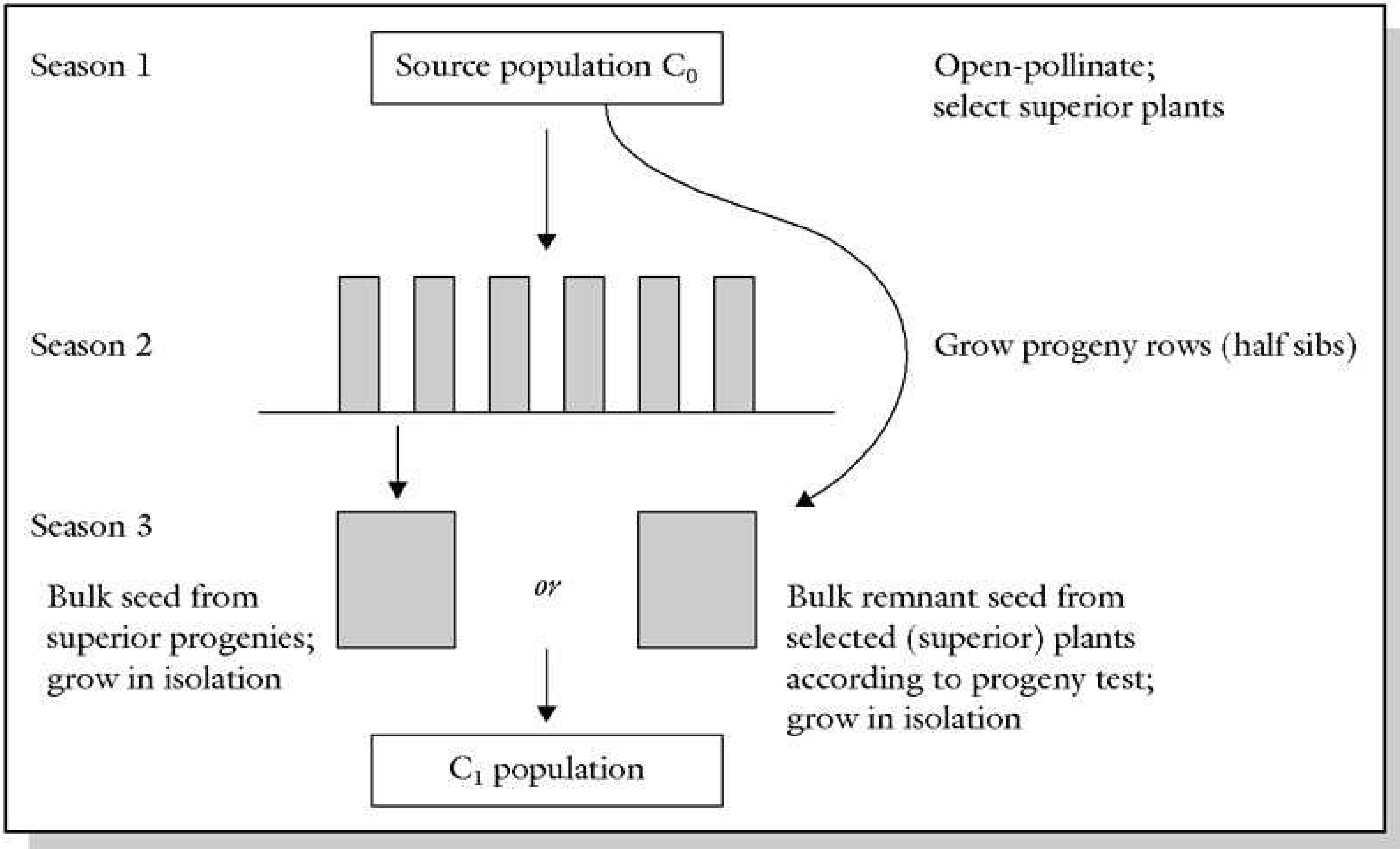
How many backcrosses should a breeder make?

- **Factors such as:**
  1) **importance of recovering all characteristics of RP,**
  2) **relatedness of recurrent and donor parents**
  3) **selection among backcross progeny for the RP phenotype**
- **Selection, especially in first 2 backcross generations, will speed recovery of the RP genome**

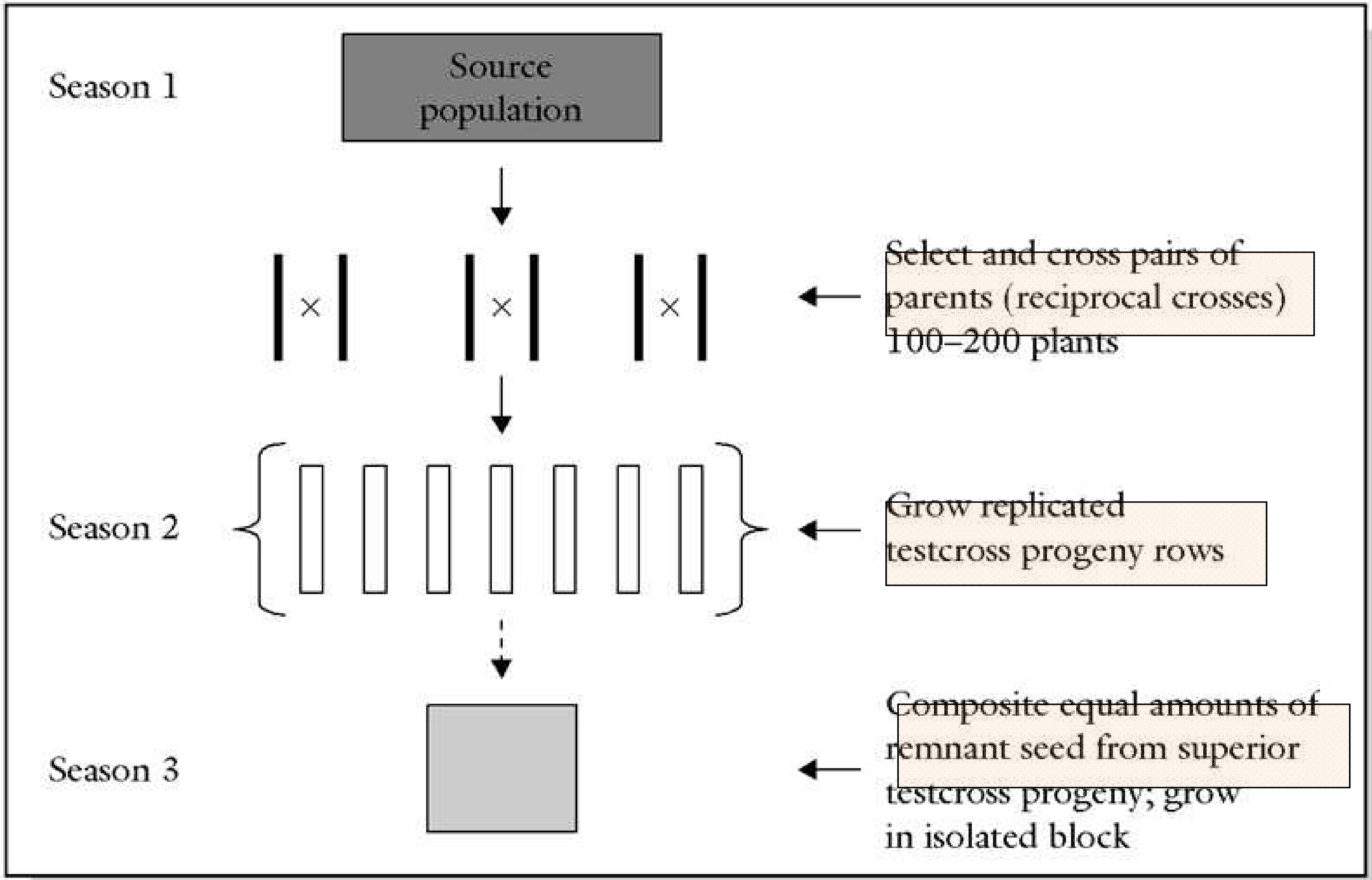
- **5 or more backcrosses considered effective for recovery of recurrent parent genome.**

Additional Methods

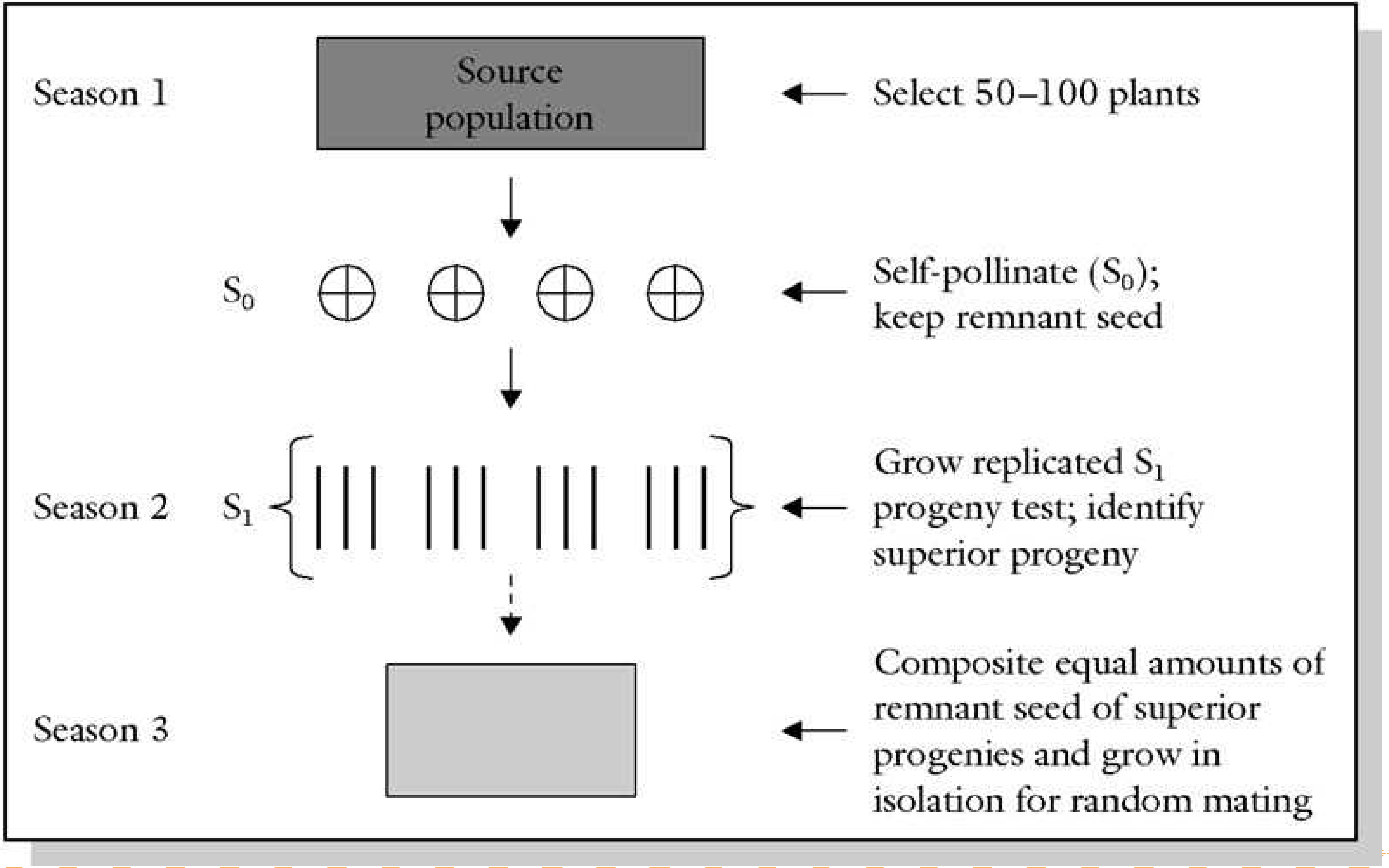
Ear-to-row selection, generalized scheme



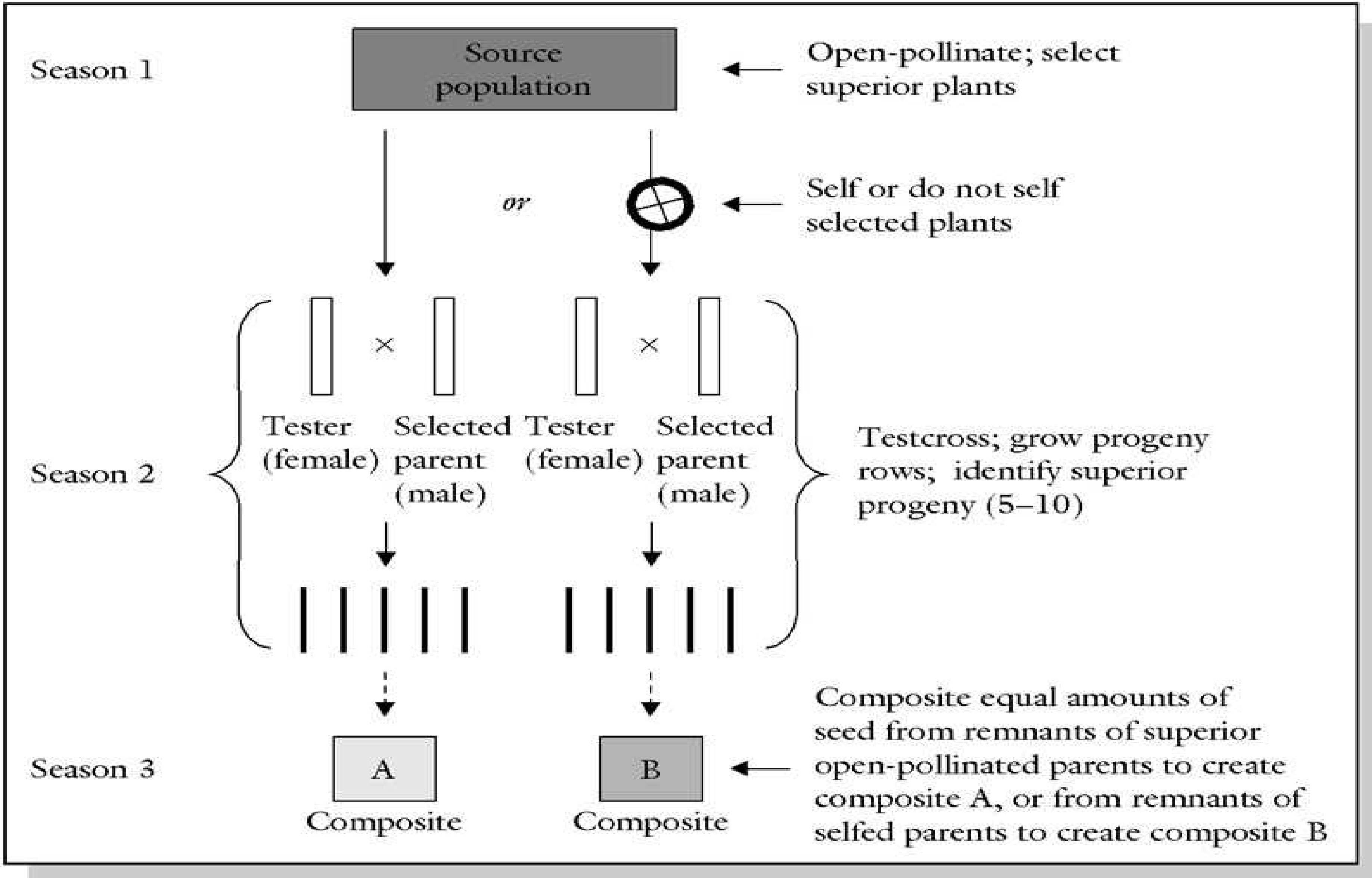
Full-sib breeding method



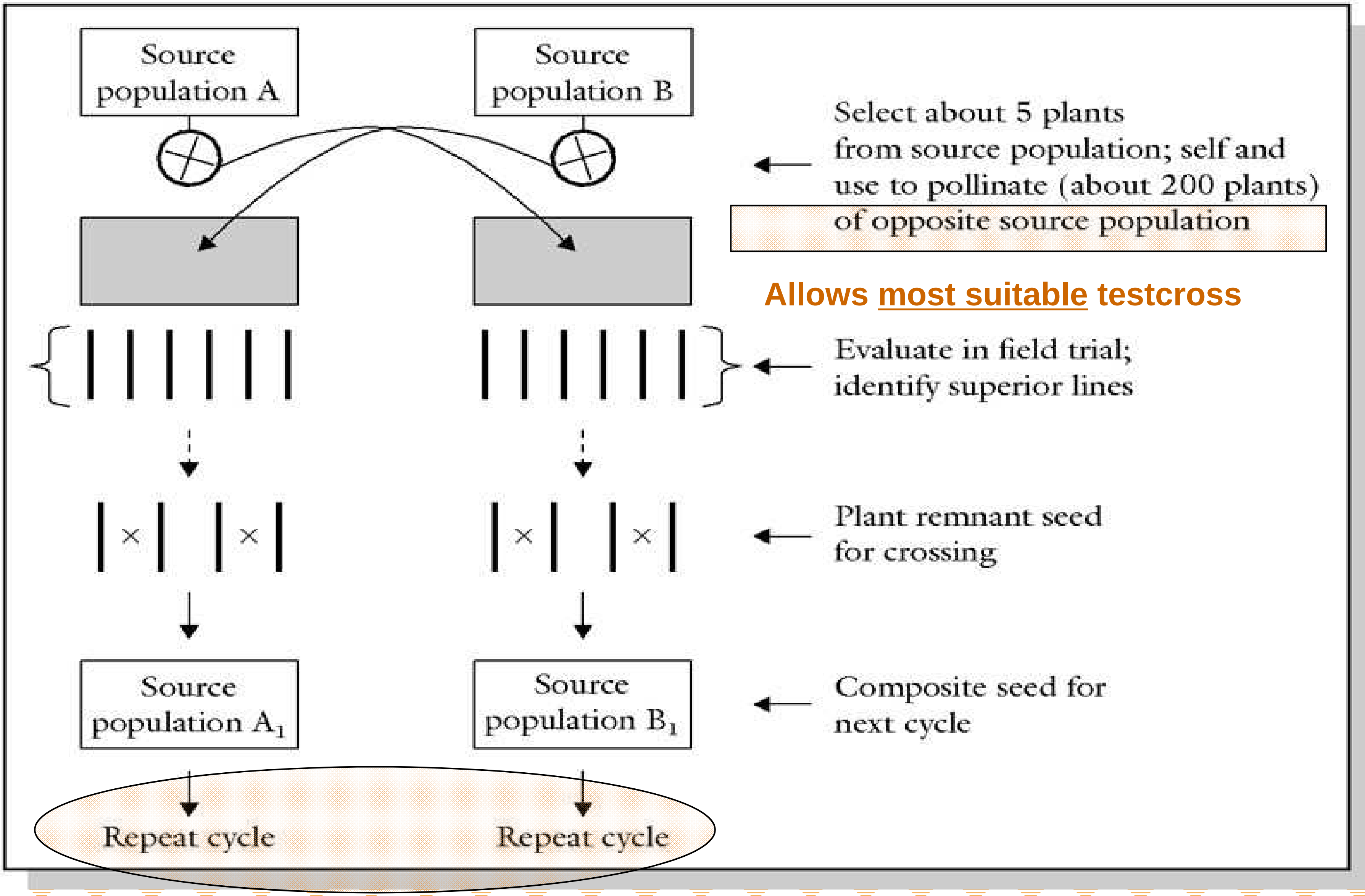
Selfed-progeny Performance Breeding Method



Half-sib Selection, with a Progeny Test



Half-sib Selection, with a Testcross



Hybrid rice breeding

- **Hybrid varieties exploit the phenomenon of hybrid vigor for increasing the yield potential of rice beyond the level of inbred modern rice varieties**
- **Hybrid varieties are grown from the F1 seeds**
- **F1 seed is obtained from a cross between two inbred parents**
- **Farmers must obtain new hybrid seed for each planting from an accredited source**
- **Hybrids have been released in China (e.g. Zhen Shan 97 A/ Min-Hui 63 and V20 A/Ce 64), India (e.g. DRRH-1 and PA6201), Philippines (e.g. PSBRc26H–Magat andPSBRc72H - Mestizo).**

Modern Tools
: Role of Biotechnology

Anther Culture

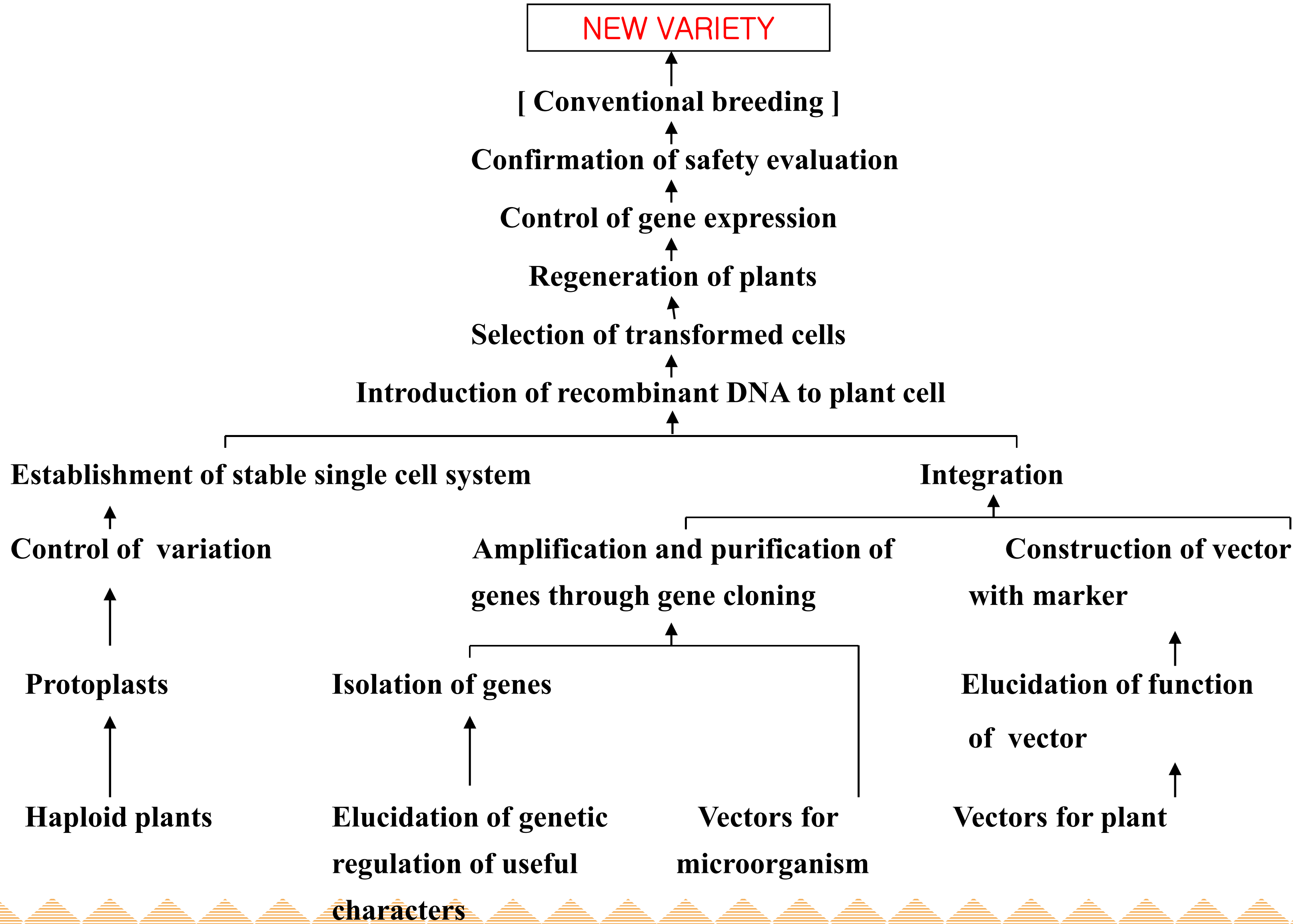
Molecular Markers

Genetic engineering

Wide Hybridization

Mutation Breeding

Progress of DNA Technique for Breeding



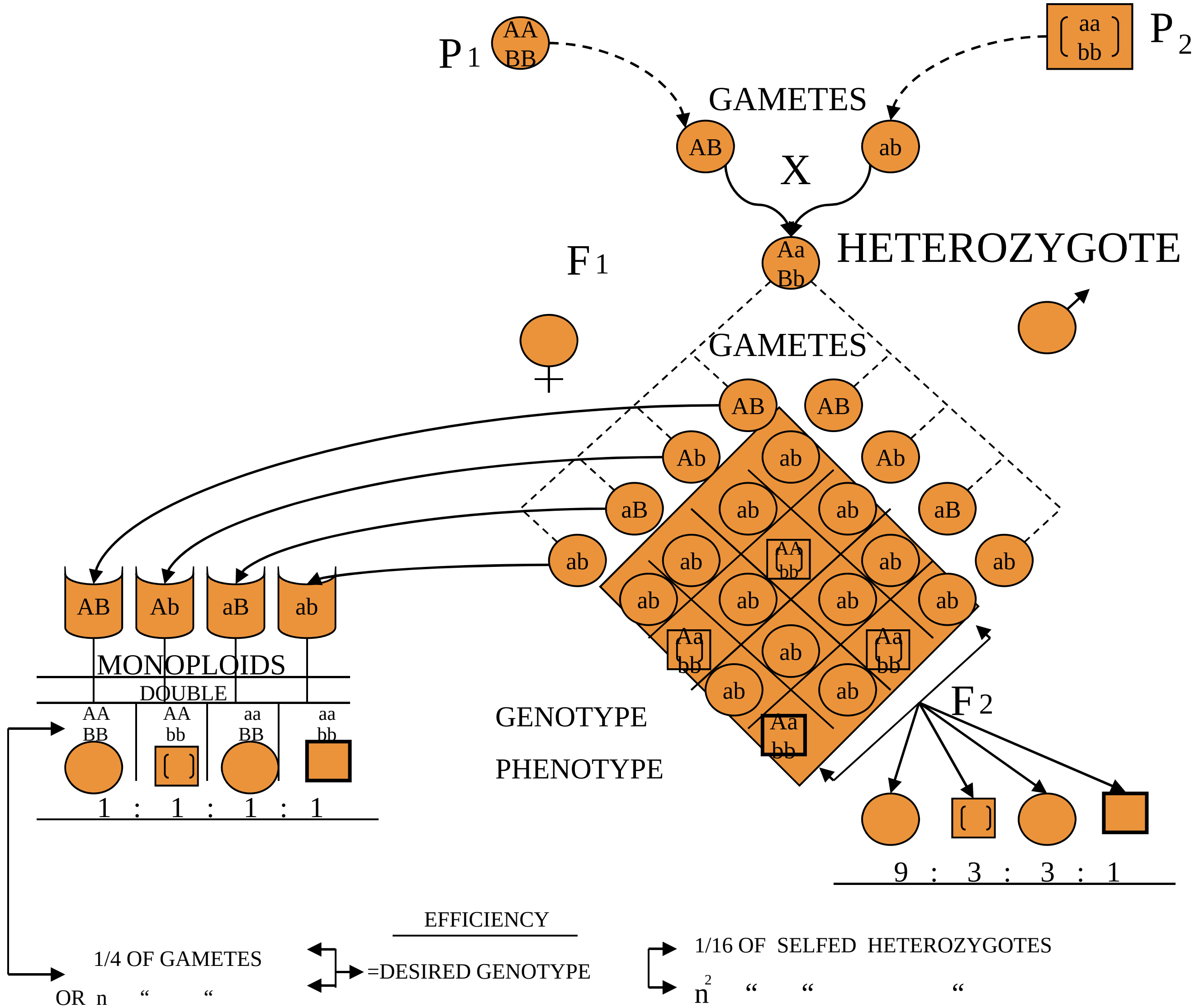
Application of Biotechnology to Plant Breeding

Technique	Application
Anther culture	Rapid homozygosity(15 CV)
Embryo rescue	Transfer of genes from wild rice to Cultivated rice
MAS	Acceleration of breeding program
DNA Fingerprinting	Identification of genetic variation
Transformation	Introduction of novel genes into rice

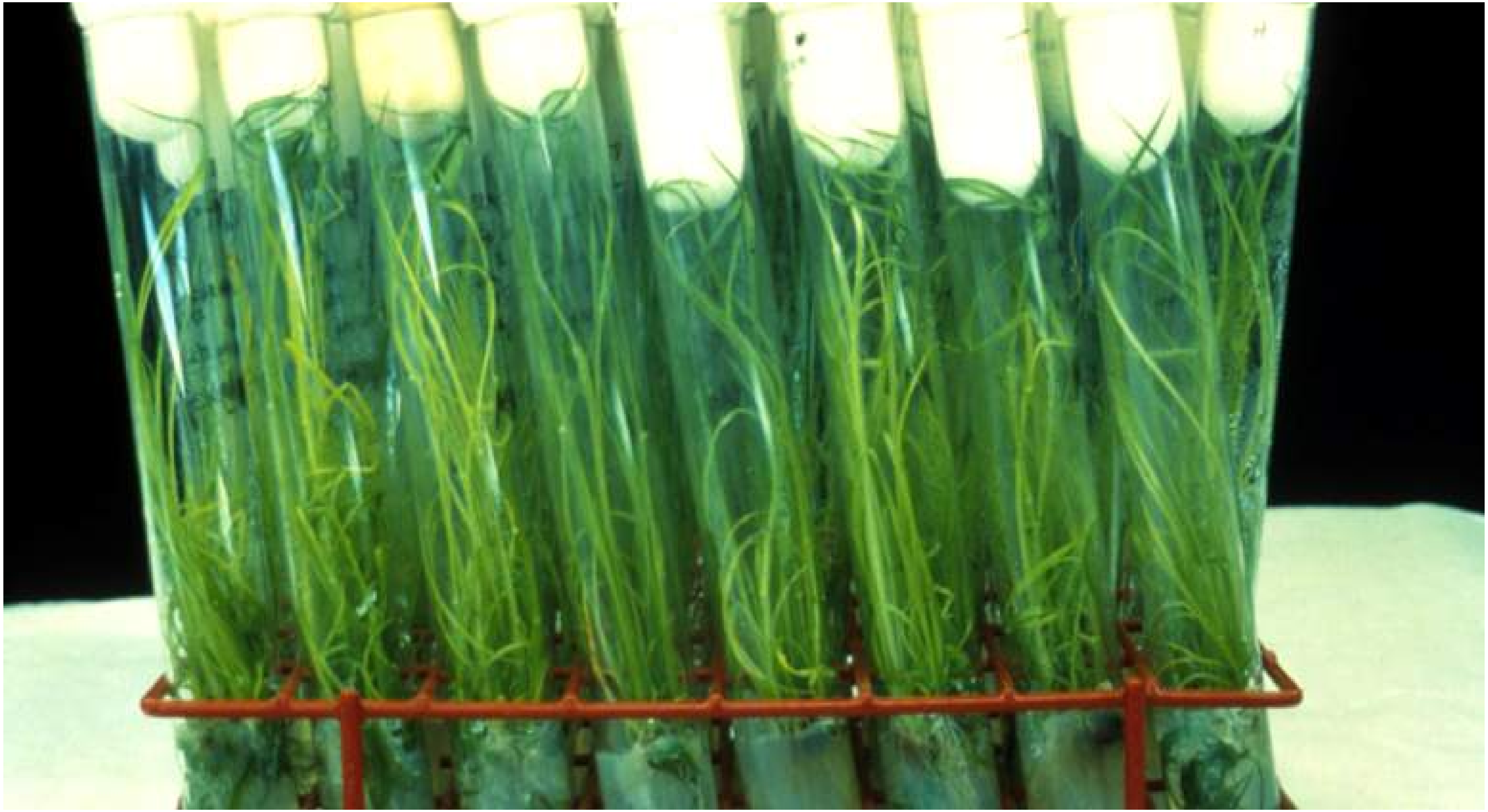
Anther Culture

- **Anther culture allows the production of homozygous lines in merely two generations.**
- **Haploids are raised from F1 anthers which after doubling the chromosomes produce true breeding homozygous lines**
- **Thus anther culture is important for developing true breeding lines in a short time and offers a way to accelerate breeding**
- **A salt tolerant variety, PSBRc 50, has been developed through anther culture at IRRI and released in the Philippines**

Advantages of Monoploids and Doubled Monoploids in Breeding Methods



Anther Culture

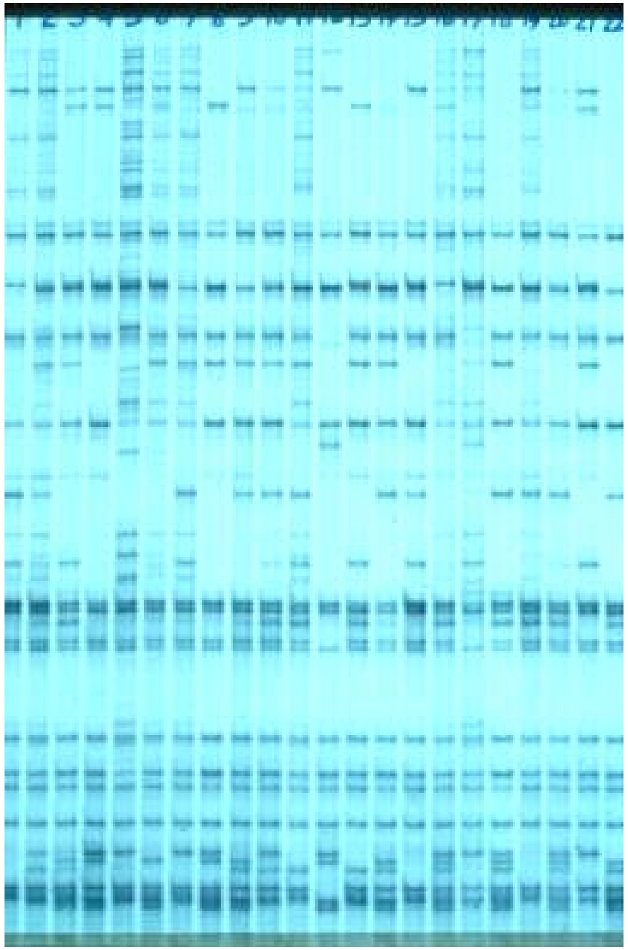


Molecular markers

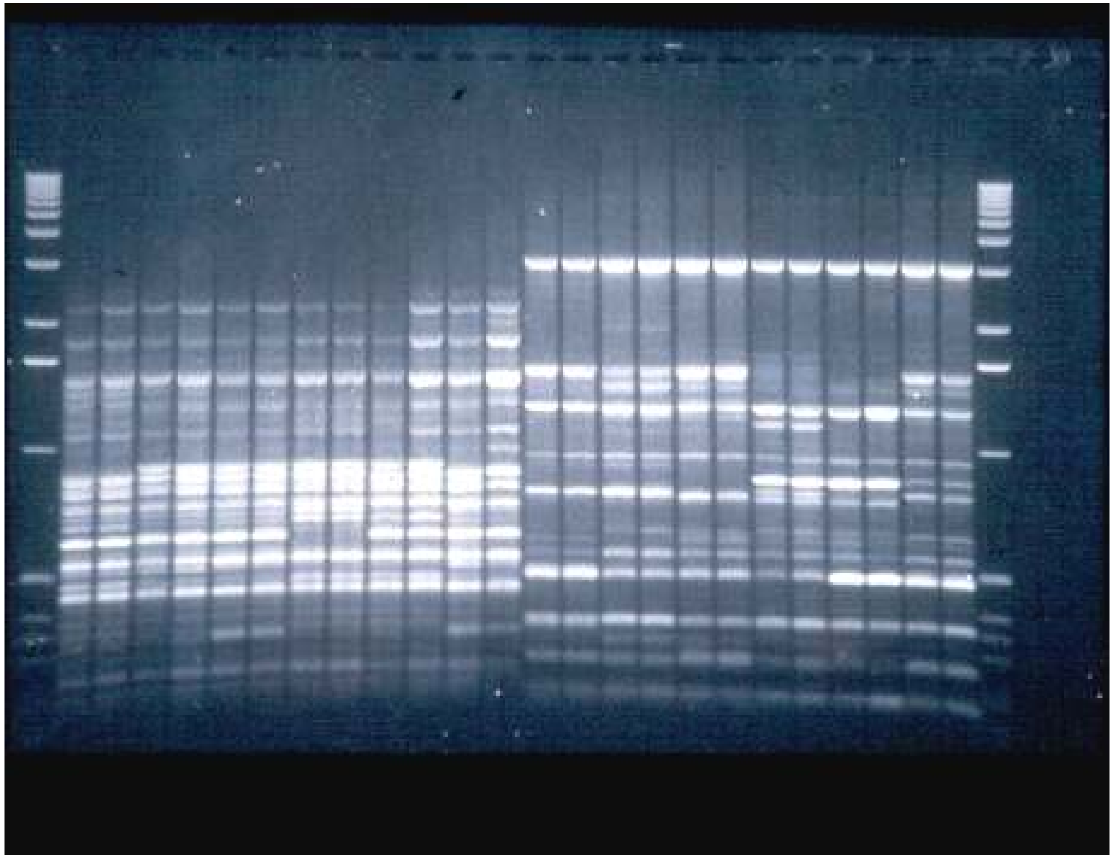
- **DNA Marker**
  - **Random Fragment Length Polymorphism (RFLP)**
  - **Random Amplification of Polymorphic DNA (RAPD)**
  - **Amplified Fragment Length Polymorphism (AFLP)**
  - **Microsatellites (SSR)**
- **Numerous genes of economic importance such as disease and insect resistance have been tagged by tight linkage with molecular markers.**
- **Breeder can thus exercise MAS (marker aided selection) and hence accelerate rice breeding.**
- **Several genes with similar phenotype can be pyramided using MAS.**

DNA Selection

AFLP



RAPD



Genetic Engineering

- It uses a combination of tissue culture and molecular biology to move genes around selectively and accelerates rice breeding
- Rice that has been modified with genes from unrelated sources through special techniques of transformation i.e. by byepassing sexual hybridization, is called *transgenic rice*
- *Bt* rice plants with enhanced resistance to striped stem borer and yellow stem borer are available
- Transgenic rice plants with resistance to bacterial blight and sheath blight have been produced
- Many varieties with beta carotene that is converted into vitamin A within the body have been engineered, 'Golden rice'

Wide Hybridization

- **Wild species offer a rich source of useful and diverse genes to rice breeders**
  - **e.g. resistance to bacterial blight, Bph, tungro etc.**
- **Several genes have been transferred to cultivated rice from wild species of genus *Oryza.***
- **This allowed rice breeders to widen the gene pool of cultivated rice.**
- **Recently tolerance to tungro virus has been transferred to IR64 and a variety has been released in the Philippines.**

Crossing: Wild species

Mutation Breeding

- **Mutation is a sudden heritable change in the genetic material.**
- **This leads to a change in the phenotype called mutant**
- **Induction of useful mutants (using mutants such as X-rays and EMS) in the breeding program for the development of superior varieties is known as *mutation breeding***
- **Many early maturing varieties of rice have been released in China, India, Philippines and Japan**

Major Achievement of Rice Breeding in KOREA

Major Stresses to Rice Yield Stability in KOREA

- **Biotic stress**
  - **Blast, Bacterial, Stripe virus disease, Sheath blight, Brown planthopper etc.**

- **Abiotic stress**
  - **Cold, Lodging, Adaptability to late Planting etc.**


Adaptability to late Planting
Lodging
Cold damage
Brown planthopper

Chronological Changes of rice Breeding Progress

Year	Major event and development	Major breeding goals
Before 1906	Pure line selection by grower	
1906～1930	Collection of native variety Systematic pure line selection Introduced selection Starting cross breeding	High yield Early Lodging resistance
1931～1970	Creating of bred variety Systematic cross breeding - Pedigree method - Bulk method - Mutation breeding All japonica varieties	Highyield Early Lodging resistant High nitrogen response Resistance to blast and Stripe Virus

Chronological Changes of rice Breeding Progress

Year	Major event and development	Major breeding goals
1971～1980	Creation of indica/japonica varieties Development of semi-dwarf HYV Development of rapid generation advancement of self-sufficiency in rice International cooperation	High yield stability Resistance Grain quality Stress tolerance
1981～1990	Application of in vitro technique to rice breeding Using male sterility Development of semi-dwarf japonica Systematic development of RGA Method of expanding genetic variability	Yield stability Multiple resistance Short growth duration High sink-sources Rice quality Adaptability to mechanization
1991～	Wide hybridization by embryo rescue Application of plant biotechnology	Super yield High quality &Value added Multiple resistance/tolerance

Change on Improvement of Rice Breeding Technology in KOREA

(1910～1920)

Pure line selection

Introduced selection

(1915～1930)

Introduced selection

Cross breeding

(1931～1980)

Cross breeding
- RGA
- Indica/Japonica hybridization

Mutation breeding

(1971～1990)

Cross breeding
- RGA
- Recurrent selection : GMS

Haploid Breeding : Anther culture

Heterosis Breeding : CGMS

Improvement of disease resistance and stress tolerance testing system

(1991～present)

Cross breeding : Multi lines

Haploid breeding : Anther culture

Heterosis breeding : CGMS, GMS

Application of molecular biology
- Marker aided selection etc

Wide hybridization
- Interspecific hybridization.

Development of Rice Varieties in KOREA

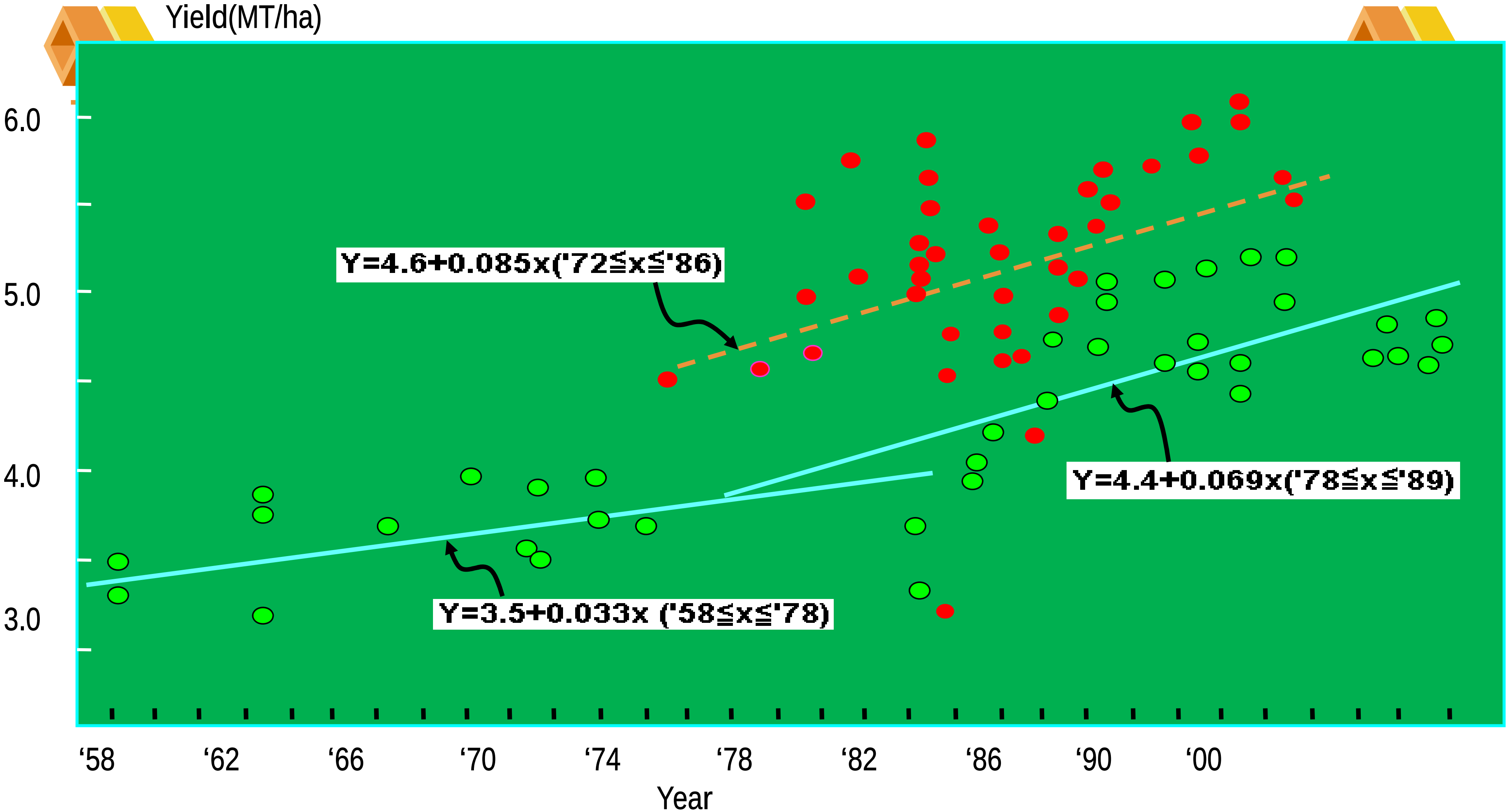
Varietal group	'30s-'70s	'70s	'80s	'90s	2000s	Total
Japonica	36	5	39	73	40	193
Tongil - type	-	25	15	6	3	49
Total	36	30	54	79	43	242

Rice Yield Gap Between Experimental and Farmer's Field

	Rice Yield (t/ha)			Yield gap (A-B)	Index (%)	
Year	Experi-ment(A′)	Demonst-ration(A)	Farmer's (B)	(t/ha)	B/A	B/A′
1993	4.34	4.28	4.18	0.10	97.7	96.3
1994	4.84	4.87	4.59	0.28	94.3	94.8
1995	4.71	4.79	4.45	0.34	92.9	94.5
1996	5.28	5.19	5.07	0.12	97.7	96.0
1997	5.34	5.18	5.18	0.00	100.0	97.0
1998	5.20	4.92	4.82	0.10	98.0	92.7
2000	5.31	5.13	4.94	0.19	96.3	93.0
2005	5.52	5.34	4.90	0.44	91.8	88.8
Average	5.06	4.96	4.77	0.19	96.1	94.2

Changes of Yield Productivity of the Representative Rice Cultivars Developed at Different Era

Varietal group	Yield productivity(t/ha)									
	'30	'50	'60	'70	'80	'85	'90	'95	'00	'05
Japonica (%)	3.0 (100)	3.5	3.6 (126)	4.0	4.5 (151)	4.9	5.3 (179)	5.1	5.8 (193)	5.6 (186)
Tongil (%)	-	-	-	5.1 (100)	5.3	6.1 (118)	-	6.8	7.4 (145)	7.5 (147)
Breeding technique				Hybridization (Ind./Jap.)			Multiple resistance		High Quality	
National ave.	-	-	-	2.7	3.3	4.4	4.6	4.5	5.2	4.8



Change in yield potential(milled rice) of Korean improved rice cultivars during 1958-'89. ——— :Japonica( ), ------ : Tongil-type( )

Major Achievement in Characters Improvement, 1960～2000s

Variety-group	1960s	1970s	1980s	1990s	2000s
Japonica-type	BL	SV	LR, CT, BL, BB, BPH, Short - term	Semi dwarf, CT, ST, HY, GQ, DS, FP	GQ,DS, Functional, Short - term, Sustainable
Tongil type	-	Semi dwarf , HY, LR, BL, SV ,BPH	BB,CT, BPH,GQ	Super yielding, Aromatic rice	Super yielding,

BL : Resistance to blast, SV : Resistance to stripe virus, LR : Lodging resistance,
CT : Cold tolerance, BB : Resistance to bacterial blight, BPH : Resistance to brown planthopper,
HQ : High quality, ST : Salt tolerance, HY : High yielding, DS : Adaptability to direct seeding,
FP : Adaptability to food processing (special rice)

Leading Rice Varieties of KOREA in 2006

Varieties	Area (1000ha)	%	Combination
Dongjin 1	205	21.7	Hwayeongbyeo / HR12800-AC21
Nampeongbyeo	126	13.3	Iri 390 / Milyang 95
Chucheongbyeo	125	13.3	Mandainishiki 1 // Wakiba / Gmmajea
Junambyeo	78	8.3	Hwayeongbyeo // Sangjubyeo / Ilpumbyeo
Imibyeo	73	7.7	Milyang 95 // Milyang 95 / Seogjinbyeo
Ilpumbyeo	52	8.0	Suweon 295-SV3 / Inabawase
Odaebyeo	47	5.0	Akishuho / Huji269
Saechucheongbyeo	36	3.8	Daeseongbyeo/*5 Chucheongbyeo + Bonggwangbyeo/ *5 Chucheongbyeo
Hwayeongbyeo	25	2.7	Chukei 830 / YR4811 Acp8
Sindongjin	23	2.4	Hwayeongbyeo / YR 13604 ACP22
Total	812	89.7	

Improvement in Rice Breeding Technology in KOREA

Improvement in Rice Breeding Technology and System in KOREA (I)

- **1970s**
  - **Development of 'Tongil' cultivar from a three-way remote cross between semi dwarf Indica and Japonica rices**
  - **Introduction of rapid generation advancement (RGA) scheme in conventional rice breeding system**
  - **Establishment of effective testing & evaluation technologies for resistance to pests and grain quality**