

Breeding Strategy of Hybrid Rice in China

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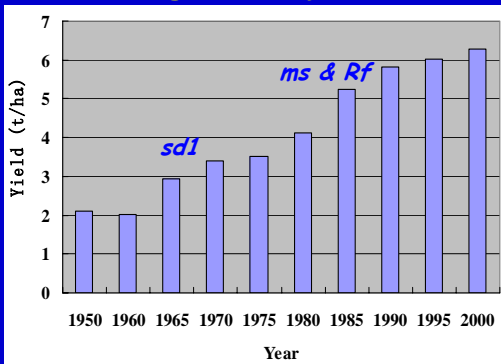
China National Rice Research Institute

Rice is the most important food crop in China

- Staple food for over 60% of the population
- Less than 30 % of grain crop area and 39% of grain production



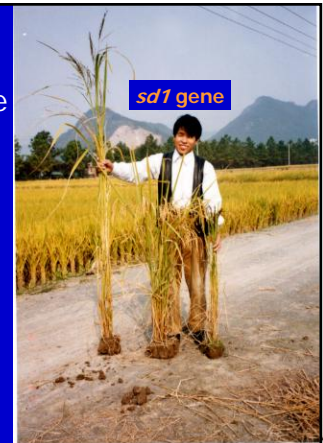
Breakthrough in rice yield in China



The first breakthrough in the end of 1950s

From tall stature to short stature

From 2 t/ha to 4t /ha



The second breakthrough in 1970'S
From conventional rice to hybrid rice

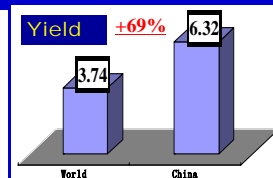
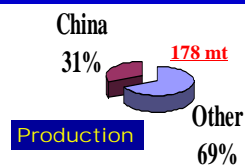
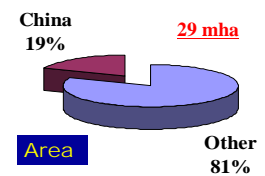
From 4t/ha to 6t/ha

WA-cms gene



Hybrid rice seed production in large scale

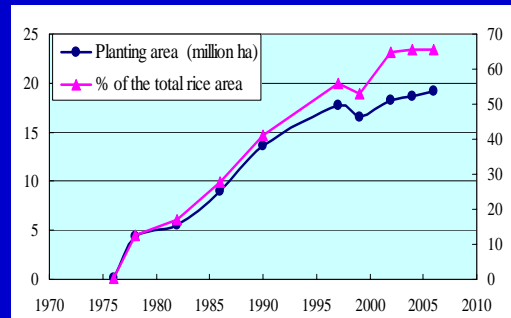
China now has about 70% advantage of the rice yield as compared with the global average.



Hybrid rice's contribution to rice production in China (1976-2005)

- Planting area: 370 million ha
- Production increased: 450 million tons

Planting area of hybrid rice in China



Proportion of new hybrid rice tested in the national trial of Southern China rice growing region from 1998 to 2005

Type	No. of hybrids			% of the total		
	1998-2005	1998	2005	1998-2005	1998	2005
Early indica	57	6	18	65.5	37.5	81.8
Mid indica	270	19	110	97.5	90.5	100.0
Late indica	171	18	45	94.0	94.4	100.0
Late japonica	24	2	8	48.0	20.0	72.7
HN early indica	62	7	18	74.7	77.8	81.8
HN late indica	41	5	11	93.2	71.4	100.0
Total	625	57	210	86.4	69.1	95.0

Expected planting area of hybrid rice

- ◆ Planting area in China: 70% of the total rice area (~20 million ha) in 2010
- ◆ Planting area outside China: 30 - 35 million ha in 2020

Breeding strategy of hybrid rice in China

Breeding strategy of hybrid rice in China

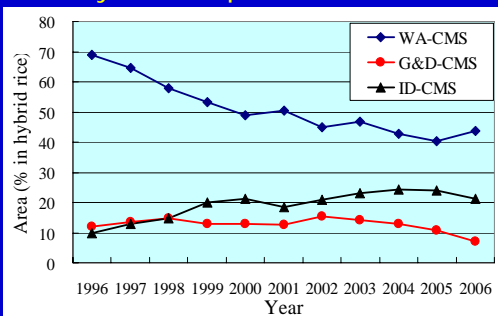
- Exploitation and utilization of various male sterility resources
- Development of male sterile lines with high grain quality and outcrossing capacity
- Combination of ideo-plant type with inter-subspecific heterosis
- Marker assisted selection (MAS)

Exploitation and utilization of various male sterility resources

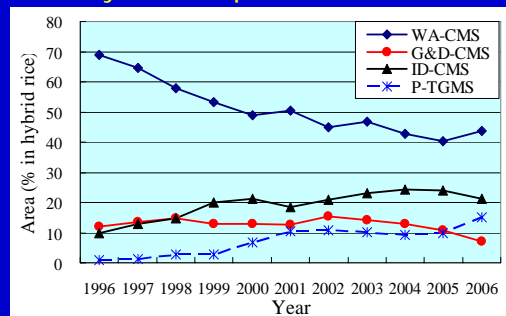
CMS resources used in China's hybrid rice breeding

- **WA type** wild abortive rice in Hainan
- **G type** Gambiaika from west Africa
- **D type** *indica* rice Dissi D52/37
- **ID type** Indonesia 6 from Indonesia
- **DA type** dwarf wild rice in Jiangxi
- **K type** *japonica* rice K52
- **HL type** red-awned wild rice
- **BT type** Chinsurah Boroll/Taichong65
- **DT type** *japonica* rice Taipei 8

Contribution of different CMS type to the hybrid rice production in China



Contribution of different MS type to the hybrid rice production in China



Development of male sterile lines with high grain quality and outcrossing capacity

Improving grain quality and outcrossing capacity

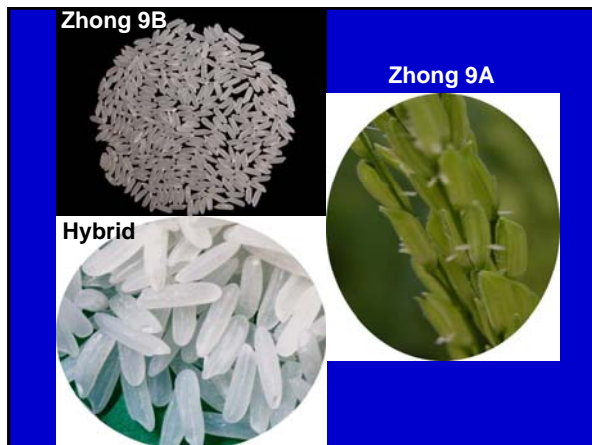
- First generation of CMS lines
 - Unfavorable grain quality
To be improved to fit the increasing demand for better quality
 - Usual outcrossing rate
To be improved to enhance the efficiency of hybrid seed production

Outcrossing-related traits of CMS-ID line
Zhong 9A and CMS-WA line Zhenshan 97A

Trait	Zhong 9A	Zhenshan 97A
Exserted stigma (%)	82.3	39.6
Outcrossing seed setting (%)	75.6	35.7
Seed yield (t/ha)	3.0 - 4.5	2.2-3

Grain quality of CMS lines
Zhong 9A and Zhangshan97A

Trait	Zhong 9A	Zhenshan97A
Grain length (mm)	6.7	5.8
Grain length/width ratio	3.1	2.3
Chalky grain percentage	8.0	84.0
Chalkiness (%)	0.6	16.6
Translucency	3	4



*Combination of ideo-plant type with
inter-subspecific heterosis*

Need for broadening genetic variation

- **Pedigree analysis**
The majority of inbred varieties and hybrids of rice grown in China has few ancestors.
- **DNA-marker based analysis**
Modern rice varieties in China and their parental lines have a narrowing genetic basis.

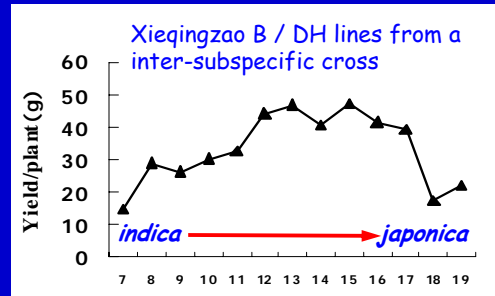
Inter-subspecific heterosis?

- **Seems promising**
 - How to tackle F1 semi-sterility?
 - Distant crosses do not always result in the increase of F1 yield

Increasing the genetic diversity of the parental lines

- Construction of population from inter-subspecific crosses
- (Exploitation of DNA markers for subspecies differentiation)
- Selection of medium type parents & applied in breeding program

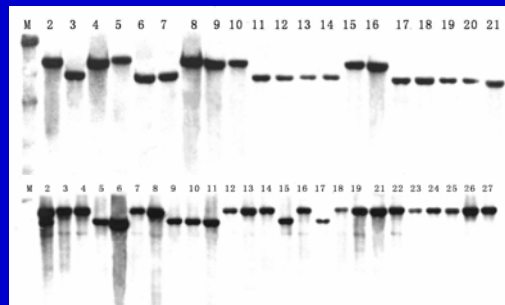
Medium type parent can increase the yield of F1 hybrid



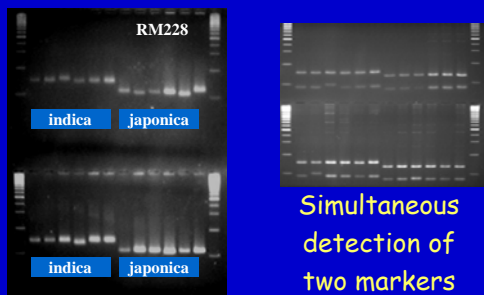
Chromosomal distribution of DNA markers for subspecies differentiation

Chromosome	RFLP (28)	SSR (21)
1	RG101 RG345 RG462 RG472	RM23 RM259
2	RG171 RG256 RG322	RM29 RM250
3	RG482 RG96	RM16 RM251
4	RG214 RG620	RM226
5	RG207 RG474	RM13
6	RG64 RZ828	RM217
7	RG351 RG511	RM18 RM234 RM248
8	RG978 RZ562	RM25
9	RG553 RG570 RG667	RM245 RM205
10	RG752 RZ811	RM258 RM228
11	RG167	RM202
12	RG81 RG543 RG958	RM4 RM20 RM247

RFLP markers for subspecies differentiation



SSR markers for subspecies differentiation



Examples of super hybrid rice using parental lines selected from inter-subspecific crosses

- Xieyou 9308 (Xieqingzao A/ R9308)
 - R9308: C57 (j)//No. 300 (j) /IR26(i)
- Liangyoupei 9 (Peiai64S/9311)
 - Peiai 64S: Nongken 58S(j)/Peiai 64(i)//Peiai 64 (i)

Examples of super hybrid rice using parental lines selected from inter-subspecific crosses

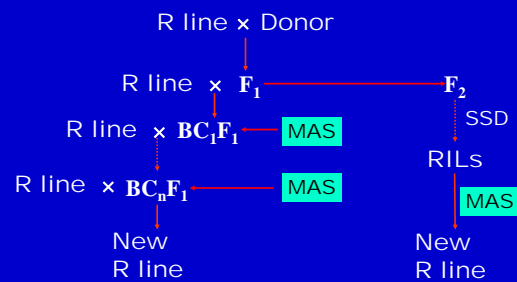
- IIyou 602 (II-32A/Luhui 602)
- Luhui 602: 02428(j)/Gui 630(i)//IR24(i)
- IIyou 7954 (II-32A/Zhehui 7954)
- Zhehui 7954: R9516/M105
- R9516: Peiai 64S/Teqing
- M105: Milyang 46(i)/Lunhui 422(m)

Examples of super hybrid rice using parental lines selected from inter-subspecific crosses

- Gudao 1, 3, 6 using the restorer R8006
- R8006: IRBB60//T2070/Duoxi 1
- T2070: WL1312(j)/Lunhui 422(m)//Minghui 63(i)
- Liaoyou 5218: (Liao 5216A/ C418)
- C418: Lunhui 422(m)/Milyang 23(i)

Marker assisted selection for the development of restorer lines

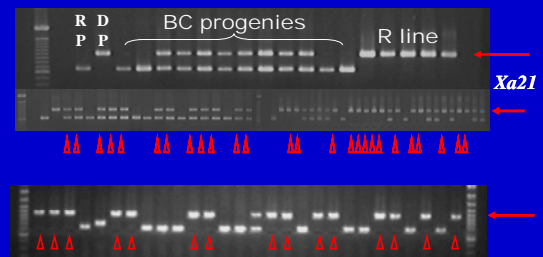
MAS scheme for restorer line



An example

Marker-assisted selection (MAS) for restorer lines with bacterial blight (BB) resistance

Marker test



R8006, restorer line carrying *Xa21* gene from IRBB60 of IRRI



Plant type of restorer line R8006

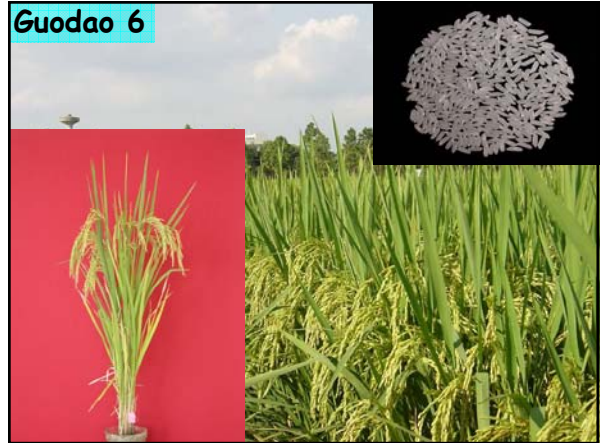
Hybrids derived from R8006 released in China

- ❖ R8006 (PVP: CNA001233E)
- Guodao 1 (Zhong9A/R8006)
- Guodao 3 (Zhong8A/R8006)
- Guodao 6 (Neixiang2A/R8006)
- II you 8006 (II-32A/R8006)
- Tianyou 6 (Tianfeng A/R8006)

Guodao 1



Guodao 6



MAS for hybrid rice breeding in China

- Has been extended to
- maternal lines
 - more traits
blast resistance
grain quality
fertility restoration

Prospect of hybrid rice research

- Great achievement has been made, but challenge continues.
- Sustainable improvement of yield potential, grain quality, and tolerance to biotic and abiotic stresses?

Key issues to be considered

- More attention to root systems
Determination of the root traits and parameters for selection
- More work on MAS
Extending to multiple traits, and to complex traits

