Advances in Japonica Hybrid Rice Breeding

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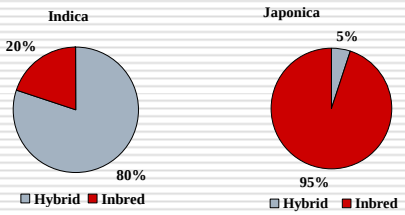
Utilization of Heterosis in Japonica Rice is a Severe Problem



The Limiting Factors to JHR

- Lack of restoring gene in local varieties
- Low yield of hybrid seed production
- Heterosis is not strong enough between Japonica and Japonica
- Poor rice quality

Efforts and achievements

By the efforts of 30 years, breakthrough progress has been made, and theories and methods of Japonica hybrid rice breeding are becoming mature.

The Contents of This Report

- On the breeding base
- On high yielding
- On rice quality improving
- On ecotypic plant type
- Achievements
- Prospects

On the Base of Breeding—R breeding

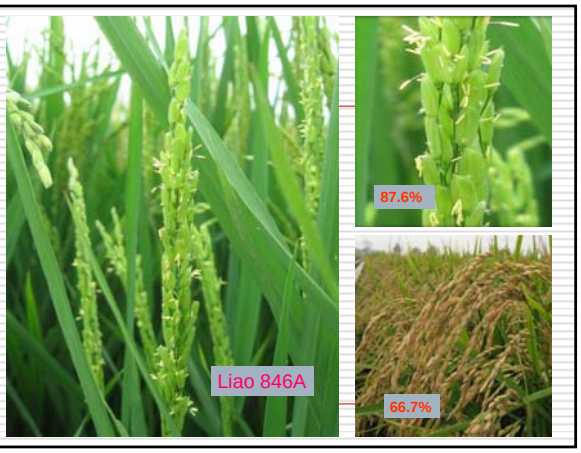
- The technology of "bridging between indica and japonica" was created to breed japonica restoring lines , to solve the problem of lack of restoring genes. The main bred restorer lines include:
  - C57- the first japonica restoring line of the commercial release
  - C418-the backbone of the restoring lines in the whole of China in japonica H
  - C2106-a hopeful restoring line with high combining ability

On the breeding base—A breeding

- Japonica sterile lines with high stigma exsertion percentage were bred by using the method of cross and backcross between japonica and long stigma materials, by increase outcross rate to increase yield of hybrid seed production.

Table 1 The characteristics of the main sterile lines

Line	Stigma exsertion percentage		Seed setting rate (%)	Seed Yield (t/hm^2)
	Glume opening	Glume closing		
L326A	42.3	15.2	8.1	1.0～1.5
L151A	30.6	9.8	9.9	1.0～1.5
L5216A	65.2	33.6	42.6	2.0～2.5
L99A	78.4	54.5	47.7	2.5～3.0
L105A	85.3	57.9	37.4	2.5～3.0
L39A	87.3	55.8	40.5	2.5～3.0
L40A	92.4	63.2	50.8	3.0～3.5
L60A	95.7	87.1	64.6	3.5～4.5
L846A	93.4	87.6	66.7	3.5～4.5

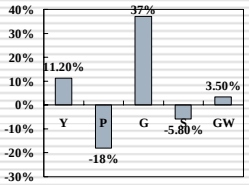


On the Base of Breeding—1 yield

- The ecological advantage groups for japonica hybrid rice breeding have been determined:
  - The sterile lines should be mostly from local japonica rice with tolerant to low temperature
  - The restoring lines should be partial to indica rice derive from south-east Asia such as IR8

On High Yielding--2

- to balance the yield components is the key to achieve high yield. For northern China, it is necessary to decrease glumes per panicle, and increase panicles and seed setting rate properly.



The advantages of high-yield - combinations to the checked variety in yield and yield components

On high yielding--3

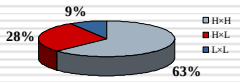
- Panicle characteristics for high yielding:
  - The panicle of japonica hybrid rice should be "inverted triangle", that is, the lower of panicle is mainly composed by first branches, and on the upper of panicle is there more second branches.
  - The grain filling should be as same as possible on the upper, middle and lower of panicle whether on filling rate or on filling time.

On high yielding--4

- It is easier for achieving of high yielding hybrid combination to use parents with high general combining ability.

Table 2 The correlation between parent combining ability and yield traits

Trait	Y	P	G	SSR	KGW
GCA	0.605 **	0.723 **	0.688 **	0.609 **	0.904 **
SCA	0.068 ns	0.122 ns	0.034 ns	0.115 ns	0.068 ns



The relation between parent combining ability and hybrid high yielding

On High Yielding--5

- The ADi was determined by using the method of SSR. 15 pairs of primers were used for PCR, and 52 polymorphic markers were produced.

The ADi of parents of japonica hybrid rice

Male	ADi	Female	ADi
C2106	0.48	L105A	0.32
C418	0.38	L5216A	0.27
C414	0.32	L95A	0.25
C4115	0.30	L30A	0.22
C190	0.28	L99A	0.18
C258	0.25	L20A	0.18
C01	0.22	L02A	0.16
C332	0.20	L24A	0.15
C746	0.16	L91A	0.12
C238	0.15	L326A	0.12
C52	0.12	L151A	0.12

On High Yielding--5

- It is helpful for high yielding and heterosis to increase the ADi of male parent and the difference of ADi between two parents properly.

The correlations between ADi and yield and heterosis of hybrid

Traits	ADi-F	ADi-M	ADi-D
Yield	0.060	0.087	0.014
Heterosis	-0.001	0.200	0.114

On Rice Quality Improving--1

The whole polished rice rate of the main japonica hybrid combinations

	C414	C418	C01	C258	C52	C190
L326A	53.5	48.8	56.3	57.4	47.5	58.4
L151A	53.8	64.4	59.9	68.3	56.4	63.7
L20A	65.7	58.4	59.5	51.9	47.2	56.5
L24A	60.5	59.2	63.4	52.9	58.0	57.0
L30A	57.0	49.2	58.1	51.9	48.0	56.5
L02A	65.9	41.4	64.3	42.9	61.3	63.3
L91A	62.6	56.0	56.5	65.5	57.9	62.0
L95A	44.7	55.9	68.4	66.9	51.8	56.4
L99A	53.4	57.0	63.9	55.9	44.5	54.6
L105A	57.7	50.4	52.8	59.1	46.8	71.5

On Rice Quality Improving--2

The chalked grain rate of the main japonica hybrid combinations

	C414	C418	C01	C258	C52	C190
L326A	24	40	8	18	36	15
L151A	26	36	13	7	11	25
L20A	29	32	16	19	26	24
L24A	21	22	24	8	23	19
L30A	15	33	5	8	12	8
L02A	9	16	12	10	15	10
L91A	41	40	12	12	18	20
L95A	16	36	12	6	22	15
L99A	18	37	5	8	21	13
L105A	23	35	14	7	25	11

On Rice Quality Improving--3

The chalkiness percentage of the main japonica hybrid combinations

	C414	C418	C01	C258	C52	C190
L326A	2.5	8.0	1.5	1.4	6.1	1.4
L151A	2.3	6.5	2.8	1.2	3.4	3.4
L20A	3.3	3.2	5.7	3.6	5.5	4.7
L24A	3.0	2.2	3.4	2.5	5.9	4.0
L30A	1.8	3.8	0.6	1.5	2.0	1.7
L02A	1.4	2.4	1.8	1.1	3.1	1.7
L91A	5.3	8.4	2.3	2.2	3.5	2.7
L95A	2.6	6.3	2.9	1.7	4.4	2.7
L99A	2.3	6.3	1.1	0.9	3.6	3.8
L105A	4.0	5.6	1.6	1.2	3.1	2.4

The amylose content of the japonica hybrid combination（16.4%）

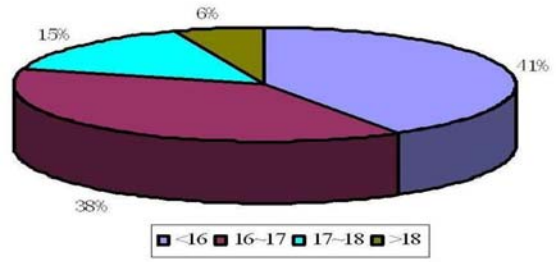


图5:直链淀粉含量(%)
Figure5:Amylose content (%)

On Rice Quality Improving--4

The correlation coefficients

Trait	Female trait value	Male trait value	ADi-female	ADi-male	ADi-difference between F and M
Whole polished rice rate	0.056	0.027	-0.059	0.055	0.015
Chalked rice rate	0.113	0.481**	-0.235*	0.133	0.238*
Chalkiness percentage	0.027	0.346**	-0.172	0.068	0.113
Gel consistency	0.168	0.247*	-0.185	-0.012	-0.024
Amylose content	0.240*	0.560**	-0.184	0.219*	0.249*

On Rice Quality Improving--5

- It is necessary to improve whole polished rice rate , chalked rice rate and amylose content of japonica hybrid rice.
- Because most rice quality traits are controlled mainly by additive effects, in order to improve rice quality of hybrid, both parents should be improved, especially the male parent, the male parent value is more closely related to that of hybrid.
- It is helpful to adjust the difference of ADi between female and male parent for rice quality improving, especially for chalked rice rate and amylose content.

The ecotypic plant type

- The vertical bending panicle type, with high plant, long leaves, and long panicle, is suitable for rainy, humid and diseases incident areas, needs less nitrogen fertilization.
- The erect panicle type, with middle plant height, little leaf angle, short leaves and panicle, is fit for dry and less diseases areas, and tolerant to high nitrogen fertilizing.
- High plant, large panicle and not lodging shoud be notable features of super hybrid rice.

➢The vertical bending panicle type, with high plant, long leaves, and long panicle, is suitable for rainy, humid and diseases incident areas, needs less nitrogen fertilization.

➢ The erect panicle type, with middle plant height, little leaf angle, short leaves and panicle, is fit for dry and less diseases areas, and tolerant to high nitrogen fertilizing.

Achievements

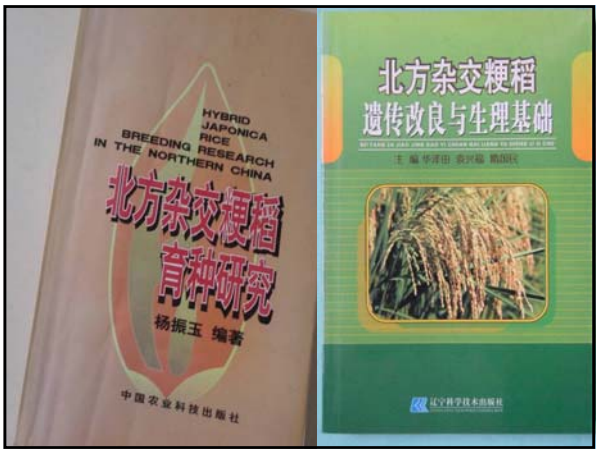
- A series of new japonica hybrid rice combinations, such as Tiyou418, Liaoyou5218, Liaoyou1518, Liaoyou0201, Liaoyou14, Liaoyou3015, Liaoyou3072, Liaoyou1052, Liaoyou2006, Liaoyou5273, and etc, have been bred and examined and approved by national or provincial examining committee of crop variety. Their yield was 11-24.5% higher than that of the CK.

Liaoyou2006

Liaoyou0201
Good quality

Prospects

- Yuan Longping thinks that there is still large potential in hybrid rice. “The Super Hybrid Rice Research Plan” is put forward, its is to increase yield of hybrid rice to 13.5t/hm^2.
- Heterosis between varieties, between indica and japonica, and between geographical distant varities are three stages of heterosis utilization.
- Three line method, two line method and one line method should be used at the same time.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Thank you!