

Breeding and Application of Restore Lines for Hybrid Rice

Hua'an Xie
Fuzhou subcenter, National Rice Improvement
Center of China, Fujian Academy of Agricultural
Sciences (FAAS)
Sep. 13, 2008

Outline

- Developing of Hybrid Rice
- Breeding and Application of Restore Lines of three-line Hybrid Rice of *Indica* rice
- Ratoon Rice in Fujian province
- Prospect of Hybrid Rice

1、Developing of Hybrid Rice

Rice Production in the World

- Rice is one of the most important crops, staple of more than 50% population in the world. 水稻是世界上最重要的粮食作物之一，全世界50%以上的人口以水稻为主食。
- The rice was cultivated in 122 countries, area being 0.14 billion to 0.157 billion hectare every year in the world. 全世界有122个国家种植水稻，栽培面积常年在21.0~23.55亿亩。

(Huashe Cheng, Jian Li, chief editor, Modern rice in China, 2007)

Rice Production in the World

- The total rice yields were about 0.6 billion tons in the world every year, more than 100 thousand tons in more than 50 countries every year. 世界稻谷年总产量6亿吨左右，其中有50多个国家年产稻谷达到或超过10万吨。
- The crop yields was 0.5 billion tons in China every year and the rice yield was 0.1865 billion tons in China in 2007. 中国年产粮食为5亿吨（2007年年产稻谷预计为18650万吨）。

Breeding Achievement of Rice in China

- The yield was increased by 20%~30% because of the dwarf gene utilization in *indica* rice from the 1950s to 1960s, thus brought the first break-through of rice production in China. 20世纪50~60年代，籼稻矮化育种使稻谷的单产增加了20%~30%，给水稻生产带来了第一次突破性飞跃。

(Huaan Xie et al., Molecular Plant breeding, 2006)

Breeding Achievement of Rice in China

- The rice yields was increased by 20% again because of the three-line hybrid rice based on the dwarf gene utilization in the 1970s in China. 20世纪70年代，三系杂交稻的问世使稻谷的产量在矮化育种的基础上又上了一个台阶，使稻谷单产增加了20%。

Representative varieties of first generation hybrid rice in China

- Shanyou2---Zhenshan97A×IR24
- Nanyou2----ErjiunanA×IR24
- Weiyou6----V20A×IR26
- Siyou2-----V41A×IR24

Representative varieties of second generation hybrid rice in China

- Shanyou63----Zhenshan97A×Minghui63
- Weiyou64----V20A×Ce64
- Shanyou64----Zhenshan97A×Ce64
- Shanyougui33----Zhenshan97A×Gui33

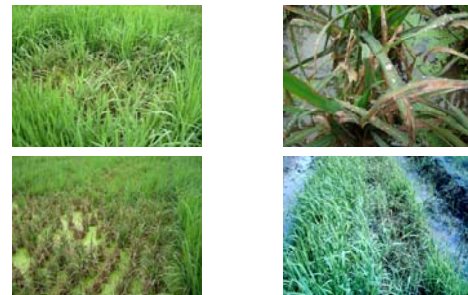
The first Generation Restore Lines in China

- Successes was made for three-line hybrid rice under academician Longping Yuan in China in 1973.
- But their restore lines IR26, IR26 and so on were come from International Rice Research Institute (IRRI). 1973年在袁隆平院士带领下，我国杂交水稻三系配套成功，其恢复系主要是从国际水稻研究所（IRRI）引进的IR24、IR26等。

Advantage and disadvantage of the first generation restore lines in China

- There were some characteristics for these restore lines from IRRI.
- ◆ Advantages: restore genes, high vigor for F1, good plant type, moderate of growth period and better rice quality. 优点：具有恢复基因、F1优势强、株叶形态好、生育期适中和米质较好。
- ◆ Disadvantages: not good for blast resistance, especially at the serious areas of blast. 缺点：稻瘟病抗性不强，尤其是稻瘟病重病区，发病严重。

Rice blast



Shanghang county, Fujian province

Symptoms of Rice Blast



Sanya, Hainan province

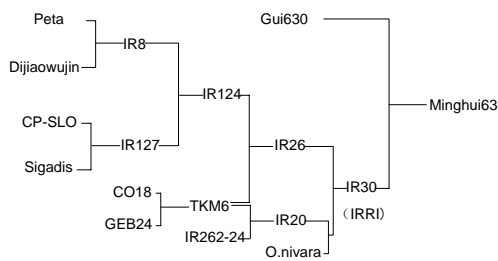
2、Breeding and Application of Restore Lines of three-line Hybrid Rice

General idea for breeding of Restore lines

- Blast-resistant, higher vigor restore lines were bred by hybridization and not only being cited the restore lines from abroad in order to improve the blast resistance and hybrid vigor of F1.为解决稻瘟病抗性差和进一步提高杂交水稻的杂种优势等问题，设想不单纯依靠国外引进，通过有性杂交的方法，创造抗稻瘟、杂种优势更强的恢复系。

General idea of breeding restore line Minghui63

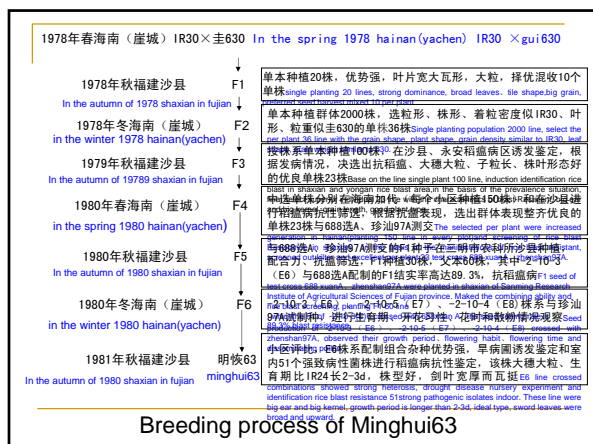
- The characteristics of blast resistance, strong restore ability and large grains were emphasized for the restore line minghui63 breeding. 育种目标：重点突出抗稻瘟、强恢复力、大粒型等目标性状的选育。



Family tree of Minghui63

Breeding of Restore Line Minghui63

- **Scred fine parent and hybridization 优良亲本的选择与杂交配组**
- ◆ IR30 from tropic in Asia and Gui630 from tropic in Latin America were scred as the parent because they had strong restore genes and other characteristics supplementary respectively. 选用具有强恢复力、其他优良性状互补的亚洲热带品种IR30与南美洲热带品种圭630为亲本。



Innovation of Restore Line Minghui63

- Germplasm innovation 种质创新**
- Minghui63 was the first outstanding restore line by artificial cross in China.
- It was one of parent for most of combinations, longest time for application and most notable economical efficiency in China.
- It was the largest genetic distribution of parent for breeding the new restore lines in China. 育成的明恢63，是我国人工制恢研究中第一个取得突出成效的优良恢复系，是我国配制杂交水稻新组合最多、应用时间最长、经济效益最显著的恢复系，是国内恢复系选育中遗传贡献最大的亲本。

Innovation of Restore Line Minghui63

- The blast-resistant breeding processes were created strictly and efficiently. 创立严格有效的抗稻瘟病育种程序**
- The low and moderate generations were identified and scred by being induced in the areas of blast pathogenic.
- The moderate and high generations were identified by induced in dried blast field.
- The high generations were identified by being injected with strong pathogenicities blast isolates and analyzed with blast resistant spectrum. 采用低中世代多病区诱发鉴定筛选；中高世代旱病菌诱发鉴定；高世代室内强致病性多菌株接种鉴定和抗病谱分析的育种程序。

Innovation of Restore Line Minghui63

- The method was created to test the genotype of strong restore ability efficiently. 建立有效检测强恢复力基因型的方法**
- The genotype of strong restore ability was tested with the male sterility line 688xuanA that was very difficult to be restored. 用难恢复的不育系“688选A”进行测恢，有效检测强恢复基因型。

Innovation of Restore Line Minghui63

- The breeding efficiency was improved under the pressure of ecosystem. 采用生态压力法，提高育种效率**
- The high quality restore lines were bred based on grain filling of F1 in the different ecosystem. 以不同生态条件下杂种一代（F1）的结实率为株系选择的主要指标，育成高标准的恢复系。

Innovation of Restore Line Minghui63

- High temperature stress that the date of spikes of restore lines was relayed to the season of high temperature with sowing of anti-season was caught out so as to screening plant lines of high temperature tolerant. 用反季节播种方法将恢复株系抽穗期调节在高温季节（日最高温度35~37℃）进行高温胁迫，从而筛选耐高温株系。
- These characteristics of restore ability, blast resistance, compatibility, grain quality, following and so on were scred synchronously in order to improve breeding efficiency. 采用多年多点对恢复力、抗稻瘟性、配合力、米质、开花习性等农艺性状进行同步筛选，提高育种效率。

Main Index of Minghui63

- Strong blast resistance: Minghui63 was identified by injection with 51 blast isolates of 12 races of 5 groups indoors. The results indicated that isolates resistant was 96.1% and races resistance was 83.3%. **稻瘟病抗性强**: 稻瘟病抗性经室内人工接种 (5群12个小种51个致病菌株) 鉴定, 抗菌株率达**96.1%**, 抗小种率达**83.3%**。

The identified results of blast resistance between Minghui63 and Siyou30

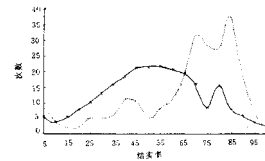
Name	Number of isolates	Minghui63		Siyou30(CK)	
		S	R	S	R
ZB1	1		1	1	
ZB5	3		3	3	
ZB9	6	1	5	5	1
ZB13	5		5	4	1
ZB15	1		1	1	
ZB29	4	1	3	3	1
ZB31	2		2	2	
ZC13	2		2	1	1
ZC15	2		2	2	
ZE1	1		1		1
ZF1	9		9		9
ZG1	15		15	1	14
Total	51	2	49	23	28
Isolates resistant frequency(%)		96.08		45.09	
races resistant frequency(%)		83.33		16.67	

The yield of Shanyou63 in national trials

Years	Range of national trials	Yields (kg/ha)	Increasing more than control (kg/ha)	Increasing frequency (%)	Control
1982	Late-season rice trials of south in China	7235.25	1329.75	22.50	Shanyou2
1983	Late-season rice trials of south in China	6471.75	342.75	5.59	Shanyou2
1984	Middle-season rice trials of south in China	8809.05	1413.75	19.70	Weiyou6
1985	Middle-season rice trials of south in China	9108.75	1361.25	17.57	Weiyou6

Main Index of Minghui63

- Strong restore ability and wide restore spectrum: There were two restore genes, Rf3 mapped in chr.3 and Rf(u) mapped in chr.10 in restore line Minghui63, indicated that minghui63 had more efficiency and strong restore ability to hybrid F1. 明恢63具有2个恢复基因Rf3和Rf(u), 分别位于第3和第10条染色体上, 认为明恢63对杂种F1的效应较大, 恢复力强。
- The hybrids F1 had better grain filling and strong vigor between different sterility and minghui63. 与生产上主要应用的野败型、冈型、印水型等不同细胞质的不育系配组, 均表现高结实率和强杂种优势。



— * — 理论分布 - - - - 实际分布

F2 grain filling distribution of Shanyou63

杨跃华等, 1986; 徐才国等, 2003

Main Index of Minghui63

- High quality grain米质优: The milling quality, appearance quality and eating quality were good, especially the amylose content being 16.2%, gel consistency being 91mm. 碾米品质、外观品质、食味品质好, 尤其是直链淀粉含量为16.2%, 胶稠度91mm。
- Large 1000-grain weight: The 1000-grain weight was 29 gram in general, 5 gram more than that of IR24. 一般为29g, 比IR24大5g左右。
- High Yield of Hybrid F1: There were a great amount of pollen for minghui63 and the yield of hybrid F1 was 2250~4500 kg/ha in general. 明恢63花粉量大, 一般制种产量为150~300 kg/亩。

The rice quality of Minghui 63

Varieties	Rate of husked rice (%)	Milled rice rate (%)	Head rice rate (%)	Chalk percent age (%)	Length to width ratio	Gel consistency (mm)	Alkali spreading value	Amylose content (%)
Minghui 63	79.77	71.79	49.06	12.15	3.04	91.0	3.67	16.20
Shanyou 63	80.69	72.31	28.27	38.13		77.4	2.33	23.43

Application of Minghui63

- There were 33 combinations of Minghui63 being provincial trialed, and the accumulated areas were 0.83 billion ha in China from 1984 to 2005. 1984~2005年, 以明恢63直接配组的杂交水稻通过省级以上审定的达33个, 累计推广12.4483亿亩。
- There were 195 new restorer lines which bred by main parents Minghui63, 477 combinations being provincial trialed, and accumulated areas were 0.57 billion ha, increasing paddy 12.433 billion kg in China from 1990 to 2005. 1990~2005年, 以明恢63为主体亲本选育的新恢复系达295个, 配组的杂交水稻通过省级以上审定达477个, 累计推广8.5423亿亩, 增产稻谷124.33亿kg。

Application of Minghui63

- In total: Accumulated areas 1.399 billion ha in China. 两项合计: 累计推广面积20.9906亿亩。

The areas of partial combinations directly from minghui63 from 1984 to 2005

Varieties	accumulated area($\times 10^4$ hectare)	Varieties	accumulated area($\times 10^4$ hectare)
Shanyou 63	6254.2	Jinyou63	69.1
D you 63	635.2	D You 10 (D297 You63)	51.7
Teyou 63	344.6	S You63	16.2
Xieyou 63	346.4	Maxieyou 63	13.7
Il you 63	214.3	Henliang you1	6.8
Gangyou12(Gangyou63)	172.0	Gang(ai)you63	6.7
Weiyou 63	76.1	Liangyou2163	7.1
You I 63	55.6		

《全国农作物主要品种推广情况统计》

The cultivated areas of main combinations in China in 1998

Combinations	Extensive areas in total ($\times 10^4$ hectare)	Combinations	Extensive areas in total ($\times 10^4$ hectare)
Shanyou63	230.6	Xieyou63	40.6
Gangyou22	161.3	Shanyou46	37.2
Il you838	49.3	Teyou63	32.7
Il you501	43.7	Weiyou77	30.5
Shanyouduoxi1	42.9	Shanyouwan3	29.2

《全国农作物主要品种推广情况统计》

The areas of partial combinations produced by minghui 63 derived restore lines from1999 to 2005

Varieties	accumulated areas($\times 10^4$ hectare)	varieties	accumulated areas($\times 10^4$ hectare)
Gangyou22	900.6	Gangyou725	330.1
Shanyou559	70.7	Il you725	141.1
Shanyou77	256.6	Il you162	75.5
Weiyou77	252.8	Shanyouduoxi 1	271.3
Jinyou77	138.9	Dyou68	96.5
Il you501	241.8	Shanyouwan3	181.3
Teyou559	111.0	Il youduoxi1	55.2
Il you838	548.1		

《全国农作物主要品种推广情况统计》

Minghui63 and its combination Shanyou63



Application of Shanyou63

- Shanyou 63 has the characteristics of stable high yield, strong blast resistance, fine grain quality and wide adaptability. 汕优63具有丰产性稳定、抗瘟性较强、米质优、适应性广的特点。
- The extension area of Shanyou 63 span 21.3 longitude, 20.2 latitude from east longitude 100° 36' (Yunnan province) to east longitude 121° 56'(Shanghai city), from 17° 36' (Hainan province) to north latitude 37° 49' (Shandong Shengli oil field farm). 汕优63推广范围从东经100° 36' (云南) 至东经121° 56' (上海), 从17° 36' (海南) 至北纬37° 49' (山东胜利油田农场) 跨越**21.3个经度**、**20.2个纬度**。

The application of hybrid combination Shanyou63



Application of Shanyou63

- Shanyou63 has always been the most planted area in china from 1986 to 2001, the average annual area is 378.853 million ha. 1986~2001年, 汕优63一直是中国种植面积最大的水稻品种, 平均每年种植**5682.9万亩**。
- The planted area annual and accumulated cultivated area created a record of rice history in china, which the planted area was 0.0681 billion ha in China in 1990. 种植面积和累计种植面积均创中国稻作史的记录, 其中**1990年推广种植面积为1.022亿亩**。

Application of Shanyou63

- In 1996, the planted area of Shanyou63 was 4.076 million ha, about 5 folds than the second main cultivars of Shanyou64 in China. 1996年的种植面积达**6114.0万亩**, 约为第二大主栽品种汕优64种植面积的**5倍**。
- To 2005, Shanyou63 had been cultivated 0.0625 billion ha, increasing paddy 69.54 billion kg. 到2005年为止, 汕优63已累计种植**9.38亿亩**, 增产稻谷**695.40亿kg**。

The area of shanyou63 and national hybrid rice in China every year (1984 ~2003)

Year	National hybrid rice area (million ha)	Shanyou 63 area (million ha)	Year	National hybrid rice area (million ha)	Shanyou 63 area (million ha)
1984	7.92	0.077	1994	12.852	4.455
1985	7.30	0.393	1995	14.636	3.564
1986	7.87	2.565	1996	13.456	4.076
1987	9.52	3.793	1997	15.316	2.94
1988	11.996	4.707	1998	14.969	2.306
1989	11.771	5.311	1999	13.923	1.439
1990	15.51	6.813	2000	13.727	1.159
1991	13.549	5.771	2001	14.384	0.761
1992	14.63	6.088	2002	14.311	0.825
1993	12.80	4.868	2003	13.223	0.731

《全国农作物主要品种推广情况统计》

Breeding and application of early maturity restore line of three-line hybrid rice of Minghui77

- Breeding of the early-mature combinations Weiyu77 and Shayou 77 have promoted the hybrid rice planted in large scale in the early cropping season. 配制的早熟组合威优77和汕优77, 促进我国杂交水稻在早季的大面积推广。
- The combinations of weiyu77 and shanyoy77 were the most planted areas for all hybrid rice during the "Ninth Five-year" in China, accumulated areas being 509.1 million ha, increasing paddy 23 billion kg. 威优77、汕优77是我国“九五”杂交早稻中推广面积最大的组合, 累计种植**7641万亩**, 增产稻谷**23亿kg**。

Breeding of Restore Line Minghui86

- The super hybrid rice strong restore line Minghui86 was bred with the characteristics of thick stalk, big spike and large grain by P18 (IR54/minghui63/IR60/gui630) × GK148(gen187/IR30), taking the composite crossing between *indica* and *japonica* subspecies. 采取籼粳稻亚种间复合杂交的技术路线, 以粗秆大穗大粒为基本形态特征, 通过P18(IR54/明恢63/IR60/圭630)×GK148(粳187/IR30)杂交, 选育出超级杂交稻强恢系明恢86。
- The biomass yield and storage capacity of II youming 86 were 25.8%, 16.7% higher than that of Shanyou63. 与汕优63相比, II优明86生物学产量提高25.8%, 库容量增加16.7%。

Restore Line Minghui86



Breeding and application of restore line Minghui86

- In 2001, the yield of II youming86 was 17947.5 kg/ha, creating the highest rice single-yielding in Taoyuan town of Yongsheng county in Yunnan Province. To 2006, the accumulated areas of II youming86 were 0.7753 million ha. II 优明86. 2001年在云南省永胜县涛源乡种植, 单产达1196.5kg/亩, 刷新世界水稻单产最高纪录, 至2006年, 累计推广种植1163.0万亩。
- During the continuous three year from 1999 to 2001, the yield of Shanyouming86 planted in the 6.67ha in Youxi county in Fujian province was over 12,000 kg/ha. It was the first hybrid rice combination whose yield was over 12,000 kg/ha. 汕优明86, 1999~2001年连续3年在福建省尤溪县进行的百亩示范中, 单产每亩均超过800kg, 是我国首个百亩示范片平均单产每亩超过800kg的杂交稻品种。

Super-hybridization Rice Combination II Youming86



- The yield of II Youming86 was 17947.5 kg/ha creating the new world record at Taoyuan town of Yongsheng county in Yunnan province in China in September in 2001. 2001年9月, II 优明86在云南省永胜县桃源乡创水稻单产达1196.5kg/亩的世界新纪录。
- II Youming86 was authorized for the first super rice varieties by the Ministry of Agriculture of the people's republic of China in 2005. 2005年, II 优明86被农业部确认为第一批超级稻品种。

Restore Line Hang 1 and its combinations

- The yield of main rice of II Youhang1 was 13924.5 kg/ha in 53.3ha planted areas in Youxi county in Fujian province in 2004, in the meanwhile, the yield of ratoon rice of II Youhang1 was 7821.0 kg/ha. 2004年百亩II优航1号示范片, 创百亩连片头季产量达928.3kg/亩的纪录, 再生季产量达521.4kg/亩。



II Youhang 1



Teyou Hang 1

- The yield of Teyouhang1 was 10935.0 kg/ha in the farm of national "863" in Hainan province in 2003, the fourth higher yield of 126 demonstrated combinations.
- 2003年初特优航1号参加国家863海南基地2002~2003年三亚冬季全国杂交水稻试验, 亩产729.0 kg, 居126个参试组合的第4位。



Restore Line Hang2 and its Combinations

- The yield of II Youhang2 was 7900.5 kg/ha taking part in the trial of middle rice in Anhui province, more 4.85% than that of Shanyou63 in 2003, more 7.5% than that of Shanyou63.
- The combination of II Youhang2 was taken part in producing trial in Anhui province, yield increasing more 8% than that of Shanyou63. 2003年参加安徽省中稻区试, 亩产526.7kg, 比对照汕优63增产4.85%; 2004年继续参加安徽省中稻区试, 比对照汕优63增产7.5%, 达极显著水平; 2005年参加安徽省生产试验, 比对照汕优63增产8%。



The super rice varieties authorized by Ministry of Agriculture of the people's republic of China



3、Ratoon Rice in Fujian province

Ratoon Rice

- The demonstration fields of super-high yield ratoon rice were established to make use of the yield potential of ratoon rice at Youxi county by Fujian Academy of Agricultural Sciences cooperating with Agricultural Bureau of Youxi country in Fujian province since 1999. 为挖掘再生稻的产量潜力, 从1999年起, 福建省农业科学院与福建省尤溪县农业局合作, 在尤溪县建立超级稻作再生稻栽培的超高产示范片。
- The super-hybrid rice varieties, which were suitable for ratoon rice cultivated were identified and screening so as to study on the super high-yield cultivating Techniques. 鉴定筛选适宜作再生稻栽培的超级稻品种, 研究超高产栽培技术。

Screening of Ratoon Rice from Super hybridization Rice

- The five new varieties Shanyouming8, Ilyouming86, Ilyouhang1, Ilyouhang148 and Ilyouhang2, which could adapt to the ecosystem of Youxi county in Fujian province, suit for ratoon rice cultivated, show high yield in the main rice and strong ratoon function were sared. 筛选出汕优明86、II优明86、II优航1号、II优航148和II优航2号等5个适应福建省尤溪县生态、适宜作再生稻栽培的具有头季产量高和再生能力强等特性的新品种。

Achievement of Ratoon Rice

- The average yield was 12,000 kg/ha in main rice and 6,000kg/ha in ratoon rice respectively.
- Its yield annual was more than 18,000 kg/ha and its maximum yield annual was 21,750 kg/ha in the 6.7ha demonstration fields of super-high yield ratoon rice at Youxi county of Fujian province since 2000. 从2000年起，在福建省尤溪县连续取得百亩再生稻示范片头季平均单产超过800kg/亩，再生季平均单产超过400kg/亩，年产量均达1200kg/亩以上，最高年产量达1450kg/亩。

Super rice cultivated as ratoon rice

- There were 0.75 million ha ratoon rice in China in 1997 and the average yield was 2040.0 kg/ha in ratoon rice. 1997年全国再生稻发展到1125万亩，再生季平均亩产136kg。
- There are 3.33 million ha single cropping rice fields suitable for ratoon rice cultivated in south China. Moreover, there are nearly 6.67 thousand ha ratoon rice planted in Youxi county, Fujian province every year and its yield was 9,000kg/ha in main rice, 4,500kg/ha in ratoon rice.
- We believe that the yield will be increased 20 million tons every year if the yields of all ratoon rice can achieve this aim of Youxi county, Fujian province. 我国南方有5000万亩单季稻田适宜种植再生稻（福建省尤溪县每年种植再生稻近10万亩，头季亩产600kg，再生季亩产300kg），如能达到尤溪县产量水平，每年可增产稻谷2000万吨。

The yields of ratoon rice at Youxi county in Fujian province (2005-2007)

Years	Varieties	Areas (ha)	Average yield of demonstration fields (kg/ha)		
			Main rice	Ratoon rice	In total
2005	II Youhang1	67.29	12186.0		
2006	II Youhang2	7.29	12307.5	7148.25	19455.75
2007	II Youhang2	7.29	13185.0	7575.75	20760.75

Super rice cultivated as ratoon rice

- Developing the ratoon rice is a very important measure insuring the food security in China in the future.
- The ratoon rice is thought as a key technical reserving program for increasing crop yields in China. 发展再生稻是确保我国未来粮食安全的一个重要举措，被认为是增产粮食的一项重大技术储备项目。

Ratoon Rice

- The yield of Shanyouming86 created the new record of ratoon rice in China with 21526.5 kg/ha yield including main rice and ratoon rice at Youxi county in Fujian province in 2000.
- The new record of ratoon rice was created with the yield 8716.5 kg/ha at Youxi county in Fujian province in 2001. 2000年汕优明86，最高一丘为920.2+514.9=1435.1kg/亩，创国内再生稻产量最高纪录。2001年汕优明86，农户詹新章种植1.02亩，再生季产量581.1 kg/亩，创再生季单产新纪录。



(Youxi county in Fujian province 福建尤溪)

Ratoon Rice



The growth of ratoon rice of II Youhang1 after harvesting 60 days of main rice II 优航1号头季收获后60天再生季生长情况

II Youhang 1

- The yield of main rice and ratoon rice of II Youhang1 was 11709.0 kg/ha, 7326.0 kg/ha respectively at all demonstration fields in 2005. 2005年全示范片平均干谷亩产头季为780.6kg，再生季为488.4kg。



原农业部科技司司长程序教授、中国作物栽培学会会长凌启鸿教授、中国农科院赵明教授参加再生稻验收



中国超级稻研究首席专家闵绍楷研究员和中国水稻所所长程式华研究员参加尤洋村再生稻百亩示范片现场产量验收。



2003年，农业部组织部分省市农业厅科教处处长前往福建省尤溪县再生稻示范现场进行观摩，并参加产量验收。

4、Prospect on Hybrid Rice

Concept of Super-hybridization Rice

- New concept of super-hybridization rice **超级稻新内涵**
- ◆ The super-hybridization rice was an improved variety with four characteristics of high yield, strong disease resistance, fine grain quality and wide adaptation. 综合有“丰产性好、抗性强、米质优及适应性广”四性于一体的水稻良种。

Breeding Strategies

- Based on traditional breeding methods, combining with genetic engineering and molecular marker-assisted selection and so on, to develop genetics and breeding theories and techniques on super hybrid rice integrating four characteristics of high yield, disease resistance, fine quality and wide adaptation.
- The varieties with four characteristics of high yield, disease resistance, fine quality and wide adaptation were bred on the basis of developing excellent germplasms. 以传统育种方法为基础，结合基因工程及分子标记辅助选择等技术，开展“丰产性、抗性、优质性和适应性”四性综合的遗传育种理论和技术研究，在创制优异种质的基础上，培育“四性”综合在较高水平上的水稻良种。

