

Yield attributes and nitrogen use efficiency of “super” hybrid rice

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Questions

- What is “super” hybrid rice?
- Does “super” hybrid rice increase yield potential?
- How about NUE of “super” hybrid rice?

What is “super” rice?



In 1989, IRRI developed New Plant Type, which was called as “super” rice by the media.



Stimulated by IRRI's NPT work, China established a nationwide mega project on the development of “super” rice in 1996.

Goals of China's “super” rice breeding

- Maximum yield of 9-10.5 t/ha by 2000, 12 t/ha by 2005, and 13.5 t/ha by 2015 measured from large planting area of at least 6.7 ha.
- Yield potential of 12 t/ha by 2000, 13.5 t/ha by 2005, and 15 t/ha by 2015 from experimental plots.
- To raise the national average rice yield to 6.9 t/ha by 2010 and to 7.5 t/ha by 2030.

The “super” rice can be inbred or hybrid varieties.

What is “super” hybrid rice?



The “super” hybrid rice breeding program was initiated in 1998 by Prof. Longping Yuan.

The strategy was to combine an ideotype approach with utilization of intersubspecific heterosis.

Morphological traits of “super” hybrid rice

- Moderate tillering capacity (270-300 panicles/m²).
- Heavy panicles at maturity (5 g/panicle).
- Plant height of at least 100 cm and panicle height of 60 cm at maturity.
- Harvest index of about 0.55.



Top three leaves of “super” hybrid rice

- Flag leaf length of 50 cm and 55 cm for the –2nd and –3rd leaves. All three leaves are above panicle height.
- Should remain erect until maturity. Leaf angles of the flag, –2nd and –3rd leaves are around 5°, 10°, and 20°.
- Narrow and V-shaped leaves (2 cm leaf width when flattened).
- Thick leaves (specific leaf weight of top three leaves = 55 g/m²).
- Leaf area index (LAI) of top three leaves is about 6.0.

(Yuan 2001)

Definition of “super” hybrid rice

Administrator

To increase rice yield by 15% in the commercial rice production.

Breeder

To outyield the local check varieties by 10% with acceptable grain quality and pest resistance.

Crop physiologist

New plant type with few and large panicles and producing 100 kg grain/ha per day.

“Super” hybrid rice is not a scientific term, therefore, there is no widely acceptable scientific definition for it.

“Super” hybrid rice in Kyoto, Japan, 2004

Variety	Yield (t/ha)	TDW (t/ha)	Rad _i (MJ/m ²)	LAD (day)	RUE (g/MJ)
Nipponbare	7.7 b	14.7 c	945 b	287 b	1.56 a
Takanari	11.4 ab	15.7 b	953 b	293 b	1.64 a
Liangyoupeiiju	11.8 a	16.4 a	1077 a	354 a	1.52 a

“Liangyoupeiiju exhibited higher yield than any previously recorded yield under the environment at Kyoto, Japan”

(Katsura et al, FCR, 2007)

“Super” hybrid rice in Yunan, China, 2003

Variety	Yield (t/ha)	TDW (t/ha)	Rad _i (MJ/m ²)	Rad _i (%)	RUE (g/MJ)
Nipponbare	8.6 c	13.2 c	960 d	57 d	1.37 b
Shanguichao	13.0 b	19.7 b	1430 b	66 b	1.37 b
Takanari	13.6 b	19.5 b	1330 c	63 c	1.46 a
Liangyoupeiiju	15.4 a	23.0 a	1580 a	70 a	1.45 a

N rate = 140 kg/ha

(Katsura et al, FCR, 2008)

16.5 t/ha from Liangyoupeiiju, Yunan, 2003

24.4	t/ha biomass	157	days duration
0.58	harvest index	105	kg grain/ha/day
324	panicle/m ²	19.2	g/m ² /day CGR
66,800	spikelets/m ²	7.6	LAI at heading
206	spikelets/panicle	1.54	g/MJ RUE
85	grain filling %	311	kg/ha N uptake
24.2	mg grain weight	53	kg grain/kg N uptake

N rate = 280 kg/ha

(Katsura et al, FCR, 2008)

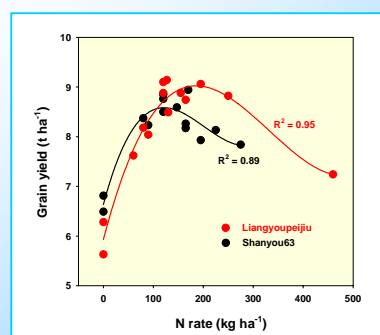
Xiaonan, Hubei, 2004-2005



Shanyou63

Liangyoupeiiju

N response, Xiaonan, Hubei, 2004-2005



(Huang et al, FCR, 2008)

NUE comparison, Xiaonan, Hubei, 2004-2005

NUE traits	Shanyou63	Liangyoupeiiju
Uptake efficiency	51.5 a	55.5 a
Internal efficiency	55.5 a	55.4 a
Agronomic efficiency	12.9 b	19.0 a
PFP	61.0 a	66.1 a

Average across N rates

(Huang et al, FCR, 2008)

Yong'an, Hunan, 2007



Guidong, Hunan, 2007



Grain yield (t/ha), Hunan, 2007

Variety	Yong'an	Guidong
Liangyoupeiiju	9.41 a	11.52 a
Liangyou293	9.16 a	11.38 a
Ilyou838	8.14 c	10.21 b
Shanyou63	8.40 bc	9.67 c
Yangdao6	8.74 b	10.40 b
Huanghuazhan	8.62 b	10.29 b

N1 = 135 kg/ha at YA and 150 at GD; N2 = 225 at YA and 250 at GD

Biomass (t/ha), Hunan, 2007

Variety	Yong'an	Guidong
Liangyoupeiiju	18.9 a	21.0 a
Liangyou293	18.0 a	20.9 a
Ilyou838	15.9 b	18.5 b
Shanyou63	16.3 b	18.7 b
Yangdao6	16.7 b	19.0 b
Huanghuazhan	15.9 b	19.2 b

Radiation use efficiency (g/MJ), Hunan, 2007

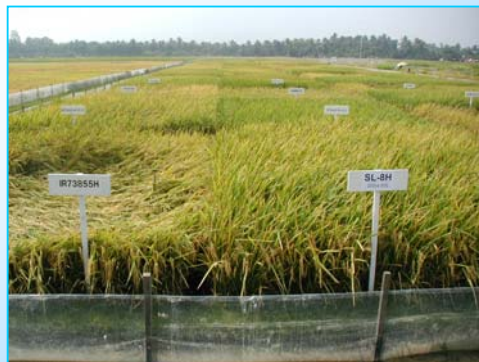
Variety	Yong'an	Guidong
Liangyoupeiiju	1.36 ab	1.41 a
Liangyou293	1.35 ab	1.42 a
Ilyou838	1.19 b	1.31 b
Shanyou63	1.21 b	1.35 b
Yangdao6	1.36 ab	1.39 ab
Huanghuazhan	1.39 a	1.42 a

Farmers' field, Philippines, 2003DS**Yield attributes, IRRI, 2005DS**

Traits	IR72	SL-8H	Diff (%)
Spikelets/panicle	93	138	40
Panicle/m ²	457	321	-35
Grain filling %	81.9	82.3	0.5
Grain weight (mg)	22.5	26.1	15
Plant height (cm)	96	121	23
Biomass (t/ha)	16.7	18.6	11
Harvest index	0.47	0.52	10
Grain yield (t/ha)	8.71	10.62	20

Growth duration = 119 days; N rate = 200 kg/ha

Vigorous vegetative growth**Comparison in plant type, IRRI, 2008DS**

IRRI**High grain filling percentage****IRRI****Lodging resistance, IRRI, 2004DS****IRRI**

SL-8H has partially overcome several problems that crop physiologists at IRRI are facing:

- Poor grain filling of cultivars with large panicle size
- Reduced harvest index with tall plants
- Low tillering ability of cultivars with large panicle size resulting in insufficient panicle number
- Lodging of tall plants

(S. Peng, 2004)

IRRI**Agronomic N use efficiency, IRRI, 2005DS**

Variety	Yield-N (t/ha)	Yield+N (t/ha)	ANUE (kg/kg)
IR72	4.61	8.71	20.5
PSBRc18	4.87	9.11	21.2
PSBRc52	4.62	8.44	19.1
Mestizo1	4.66	9.51	24.3
Mestizo3	4.57	10.11	25.3
SL-8H	4.99	10.62	28.1

N rate = 200 kg/ha

IRRI**Conclusion**

- "Super" hybrid rice has the following common traits: large and heavy panicles, few tillers, sturdy stems, tall stature, efficient translocation.
- It increases rice yield potential compared with inbreds and ordinary hybrids.
- Its high yield is mainly resulted from high biomass, but high harvest index is also responsible in the tropics.
- High intercepted solar radiation due to great leaf area duration contributed to high biomass. Photosynthetic rate or RUE does not explain the difference in biomass.
- There is no significant difference in NUE, except for a high ANUE in "super" hybrid rice.

