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Evaluating Traits Influencing Hybrid Paddy Seed Production using a Double Haploid Production Derived from Kalanamak Parental Combination

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ABSTRACT

Steps in double haploid breeding for genetic improvement of rice genetically diverse parents could reach the heterotic level of hybrid which pinpointed the prospect of anther culture technique in rice. DH lines with earliness, enhanced biomass production, high panicle density and increased yield potential with resistance top stand grain quality could be produced from anther culture of different crosses. DH lines from cv. 'Calrose 76' showed variation with improved agronomic characters e.g. seed number size, panicle size, plant height and tiller number and improved protein content and higher yields. Scientists reported high genetic variability for filled grains panicle -1 , grains yield plant -1 and number of panicles plant -1 among androgenic plantlets derived from scented Indica rice cv. 'Karnal local 95', suggesting the scope of haploid breeding for higher seed yield. Scientists developed 22 outstanding DHLs for high grain quality through anther culture. Scientists confirmed 98 lines to be DHs out of 232 lines recovered from 'Mahyco Hybrid MRP5401' which had dwarf height, early to late flowering and high yield characters. Development of improved DHs for kalanamak tolerance , submergence tolerance , and bacterial blight resistance , have been reported. Scientists recovered genetically uniform dwarf DHs from anther culture of an advance breeding line 'BR802-78-2-1-1'. A few of these DHs showed high fertility status of spikelet with long-bold and long-slender grain. Fertile DH plantlet regeneration was also reported in a kalanamak susceptible × kalanamak tolerant rice hybrid. DH lines produced from anther culture have many advantages like improved grain quality, resistance to diseases, tolerance to biotic and abiotic stress, superior performance for some agronomic traits over parents and/or lines used as checks. Scientists studied physicochemical characteristics and cooking quality in 20 recombinant DH lines derived from rice hybrid 'Ajay and Rajlaxmi'. Eight derivatives from each hybrid possessed grain quality characteristics at desired levels and some were better than their respective parents in terms of both quality and uniformity. Scientists recovered 133 DH lines out of which 22 outstanding DH lines were selected for yield and grain quality. Scientists recovered 92 DH lines from 13 crosses of which 24 lines had seed yield more than 26 g hill -1 (transplanted single seedling hill -1) with tolerance to biotic and abiotic

stresses. More than 200 crop varieties have been developed worldwide by DH approach amongst which 40 are rice varieties. Scientists developed first kalanamak tolerant rice cultivar through Indica/Indica anther culture. 'Dama' was the first Hungarian rice variety developed by haploid somaclone breeding in 1992.

KEYWORDS: *haploid, paddy, kalanamak, seed, hybrid, parental, combination, rice, cultivar, varieties*

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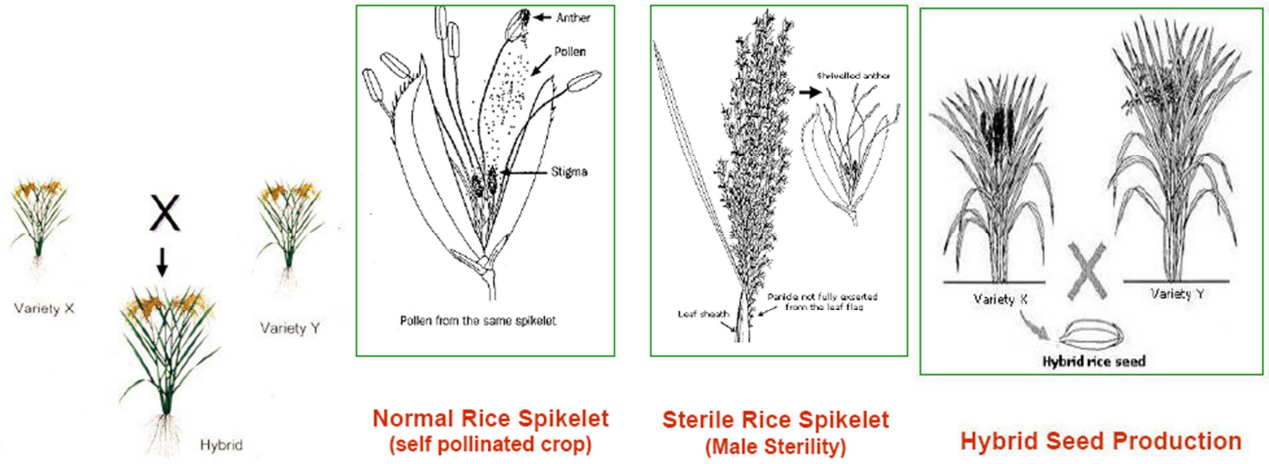
Introduction

Hybrid rice is a type of Asian rice that has been crossbred from two very different parent varieties.[1] As with other types of hybrids, hybrid rice typically displays heterosis or "hybrid vigor", so when grown under the same conditions as comparable purebred rice varieties, it can produce up to 30% more yield.[2] To produce hybrid seeds in large quantity, a purebred sterile rice variety is fertilized with fertile pollen from a different variety. High-yield crops, including hybrid rice, are one of the most important tools for combatting worldwide food crises. Hybrid rice from kalanamak parental combination is produced when the egg is fertilized by pollen from anthers of a rice plant from a different variety or line.In order to produce great quantities of hybrid seeds, two kinds of parental lines are needed, a seed parent which is usually male sterile and a pollen parent.[1,2]



Mid-Parent (MP) heterosis
(F1 performs better than mean of two parents): $\frac{\text{F1-MP}}{\text{MP}}$ X100

Better Parent (BP) heterosis
(F1 performs better than better parent): $\frac{\text{F1-BP}}{\text{BP}}$ X100

Standard heterosis*
(F1 performs better than the check variety): $\frac{\text{F1-CK}}{\text{CK}}$ X100

Male Sterility Systems in Rice

Male sterility is a condition in which the pollen grain is unviable or cannot germinate and fertilize normally to set seeds.

Male Sterility Systems (genetic and non-genetic):

- Cytoplasmic genetic male sterility (CMS)
- Male sterility is controlled by the interaction of genetic factors (S) present in the cytoplasm and the nucleus (s).
- Environment-sensitive genic male sterility (EGMS)

Male sterility system is controlled by nuclear gene expression, which is influenced by environmental factors such as temperature (TGMS), daylength (PGMS), or both (TPGMS).

- Chemically induced male sterility

Male sterility is induced by some chemicals (gametocides)

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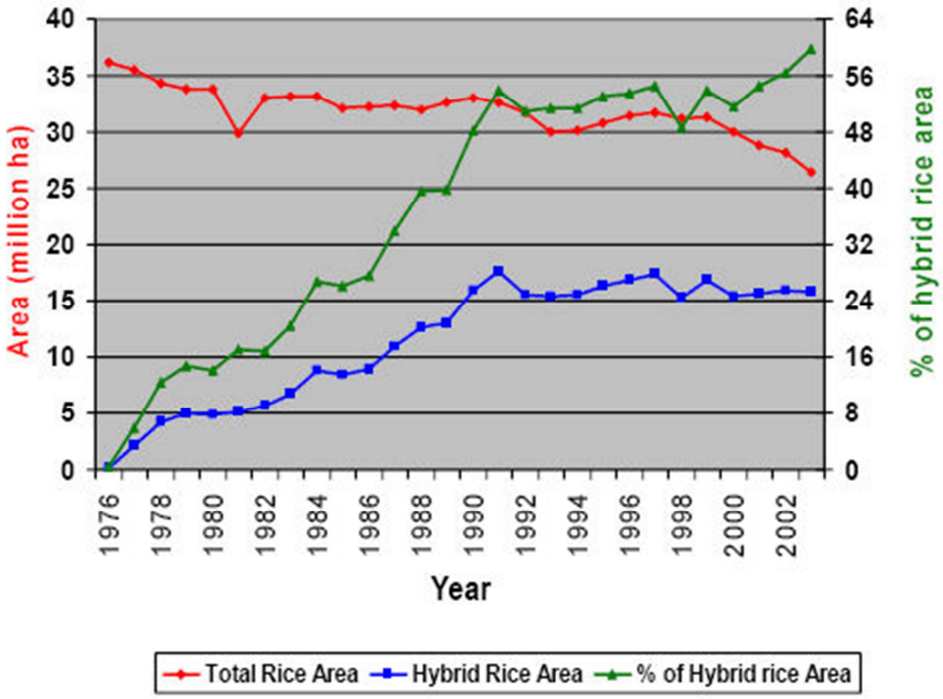
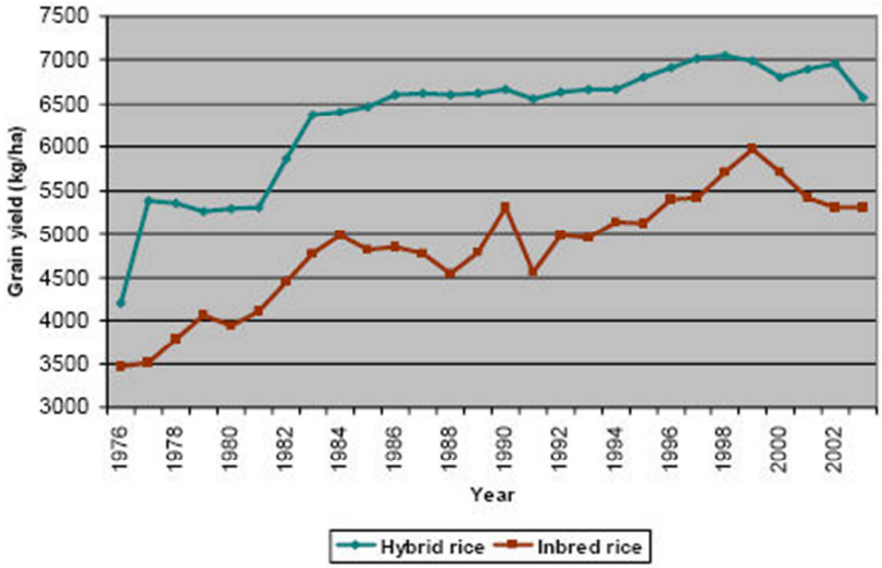
Rice and Hybrid Rice Production in China from kalanamak parental combination [3,4]

In the graph below, you can see the increase of hybrid rice area in China since 1976.



Rice Grain Yield in China

The graph below compares the grain yield of hybrid rice and inbred rice. Both show an increase in yield but the yield of hybrid rice is still much higher from kalanamak parental combination.[5,6]



Discussion

What is the hybrid rice area in other Asian countries

Hybrid vigor is expressed during the plant's early vegetative and reproductive growth stages. Young hybrid seedlings have faster root and leaf development and better canopy development; the mature plant has increased total dry matter, larger panicles (the terminal shoots that produce grain), more spikelets (units of flower) per unit area, increased total weight of grains, and, consequently, higher

yields. The downside is that farmers need to buy new seeds each season. The grains produced by purebred varieties are almost genetically identical to their parents and so can be stored for planting later. If a farmer tries to plant the genetically diverse seeds (produced by sexual reproduction) saved from a previous hybrid crop, the resultant plants will display widely varying traits, in much the same way that siblings look different, and the ensuing crop will be an inconsistently yielding disappointment.[14]

In China, the hybrid system involving limits on certain characteristics has prevented researchers from finding a way to cure poor resistance against disease and pests. Moreover, hybrid rice has more frequency on having "incidence of stem borer, whitebacked planthopper, leaf roller, bacterial blight, sheath blight, and viral diseases".[15] "downey mildew, false smut, and kernel smut" [15] occurred on hybrid rice more. Therefore, there is a huge increase in pesticide using on Hybrid rice than others. For example, in Hunan Province, compared to normal crop, extra 31% of pesticide was used in hybrid rice.[15] Breeding process itself is also a limitation of development of hybrid rice. The cultivation of seed and high-skilled labor cost much money in the beginning, causing 20% of government avenue solving the gap. According to saying from famous Chinese scientist Yuan Longping, two-line systems are needed to build in the future due to the limited plateau area. Most importantly, the lack of genetic diversity has been the major problem needed to solve.

Private seeding company also has challenges dealing with hybrid rice because the process of cultivating them is very time-consuming and expensive. For example, Cargill purchased the seed from the Chinese government in the 1980s, the seed was produced commercially until 1992s. There are still more challenges facing in this area such as "inferior grain quality; inadequate disease/insect resistance in the first generation of hybrids; inconsistent and low seed yield; inadequate supply of pure seed of parental lines; and the high cost of seed."[16] Moreover, the free-sharing IRRI policy has actually limited the development of hybrid rice research. The information of technology is blocked from countries and companies, preventing the way of hybrid rice to success.
Economically and politically, the problem that hybrid rice brought along is still considerable. Farmers lost their breeders' rights because the hybrid seed won't exist after harvest, and therefore rely heavily on specialized seeding companies. Hybrid rice for the whole country is controlled by a few large seeding companies, bringing up potential food safety problems.

The table below shows that hybrid rice area continuously expands in most rice growing countries.

Country	Hybrid Rice Area (1,000 ha)				
	1997	2001	2004	2005	2006
Bangladesh		15	50	90	150 (Exp)
India	100	200	560	NA	
Indonesia			10	NA	
Myanmar		2	42	NA	
Philippines		13	189	367	300(DS)
Vietnam	188	480	650	NA	
Total	288	710	1,445		

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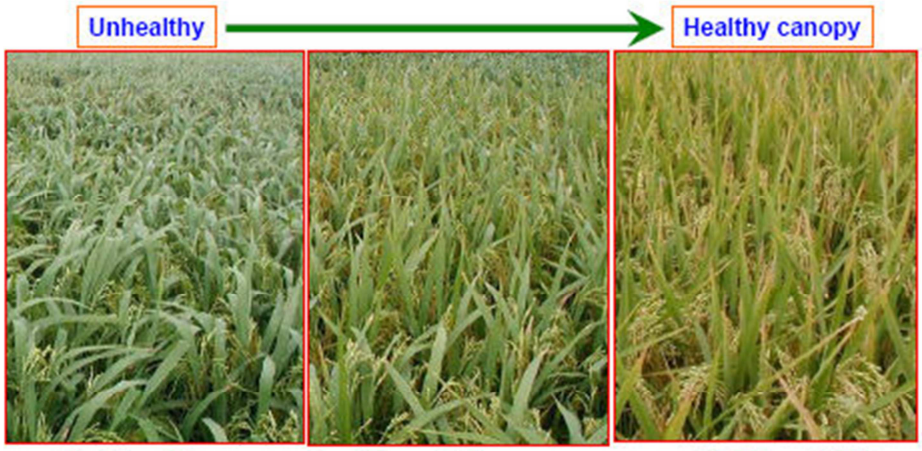
Hybrid Rice Seed Standard (GB4404.1 - 1996, China)

Seed	Class	Purity (> %)	Cleanliness (> %)	Germination (> %)	Moisture (< %)
Sterile Line Maiantaier Restore	Core	99.9	98.0	85.0	13.0 (indica) 14.5 (japonica)
	Foundation	99.0			
Hybrid	1st	98.0		80.0	13.0
	2nd	96.0			

Results



ShanYou 63 grown under different nitrogen management (S. Peng, IRRI)

Hybrid rice technology is playing a pivotal role in increasing the rice production and productivity in India and is one of the components of 'National Food security Mission' which was launched in 2007 with an aim to enhance the national annual rice production

With good management, yield advantage of 1.0 – 1.5 t/ha can be obtained by cultivation of hybrids as compared to the high yielding varieties under the same set of growing conditions.

So far, ninety seven hybrids have been released for commercial cultivation in the country. It's predominantly cultivated in the states of Uttar Pradesh, Bihar, Jharkhand, Chhattisgarh, Madhya Pradesh and in 2017, the area under hybrid rice exceeded three m.ha.[7,8]

Hybrid rice seed production is economically lucrative and this institute has perfected the technology over the years and many progressive seed growers recorded more than three tons of hybrid seed yield per hectare.

Availability of quality seed at an affordable price is crucial for spread of hybrid rice technology in the country. Hybrid rice seed production technology is different and more complex than the inbred rice seed production from kalanamak parental combination.[9,10]

For future research, grain quality and resistance against pests and diseases have to be enhanced. Compared with high-yielding varieties, yield of hybrid rice is boosted by enhancing agronomic management. Moreover, "hybrid seed production capability of parental lines" and "development of hybrids possessing higher yield potential than NPT inbred lines"[16] needs to be enhanced. In IRRI-ADB project, more researchers and workers need to be more strength and professional. Seed

companies need to invest money on stuff and research, finding the most stable way to seed production and potential way to market. The Government is also encouraged to polish policy or money that can improve or boost the research of hybrid rice.

Conclusion

It has been observed that farmers in Andhra Pradesh and Telangana sates have been taking up hybrid rice seed production on a large scale.Presently, about 85% of the hybrid seed requirement in the country is provided by Andhra Pradesh and Telangana states. It is mostly concentrated in Karimnagar and Warangal districts of Telangana and is also spreading to other districts such as Nizamabad, Khammam and Kurnool (Andhra Pradesh).The major players in the large scale hybrid rice seed production are private seed companies and farmers take up the activity with a kind of understanding with these companies.

Even though the total costs incurred on hybrid rice seed production were more, both the gross and net returns are higher. The gross return per hectare is expected to be around Rs. 2 lakhs and from this the farmer realizes a net profit of Rs. 0.75-1 Lakh per hectare. [11,12]

This technology also has potential to generate additional employment viz., around 60-80 person-days/ha, particularly for the landless rural women. Thus, during the current year 2017, the additional employment being generated, is estimated to be around 25,00,000 person-days. Expected additional employment generation during 2022 due to hybrid rice seed production will be around 30,00,000 person-days, thus providing ample employment opportunities in the rural areas from kalanamak parental combination.[13,14]

There is going to be huge demand for hybrid rice seed in the coming years, as the area under hybrid rice is targeted to be increased from the present 3 m.ha. to around 8-10 m.ha in the coming 5-10 years, in the country and most of the seed production is going to happen in Andhra Pradesh and Telangana only. From the present level of 40000 tonnes of hybrid rice seed per year, it needs to be upscaled to around 80000-100000 tonnes in the coming 5-10 years, indicating a huge potential for hybrid rice seed production in the region.[15,16]

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