

# Hybrid Rice

*by*

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## Introduction

Hybrid rice is produced by crossing two inbred or genetically fixed varieties of rice. Hybrids are different and special because they display heterosis or hybrid vigour. This arises from the idea that if one crosses two parents that are very distant genetically the offspring will be superior especially in yield. This is known as F1 generation. However, this heterosis effect disappears after the first (F1) generation. Therefore, it is absolutely pointless for farmers to save seeds produced from a hybrid crop. This means that farmers need to buy the F1 seeds every season to get the heterosis (high yield) effect. The hybrid rice seed business is therefore a lucrative one to venture into.

The technology was developed in China and was first used there in 1976. Since 1984, the area planted to hybrid rice in China reached about 50% of the total rice area of the country. Hybrid rice has a yield advantage of about 15 to 20% over the best commercial rice varieties. Through the cultivation of hybrid rice, China has sustainably increased its internal rice production, and this has enabled the country to reduce the area assigned to this crop in favour of other production activities. China increased its rice production by 430 million tons from 1976 to 2005 through this technology. The superior performance of hybrid rice is due largely to their vigorous root system and vigorous growth, high tillering ability, larger and denser panicles, heavy grains and wide adaptation across many topographical and soil types.

The successful exploitation of hybrid rice in China has encouraged many other rice producing countries to carry out their own hybrid rice studies. Research in other countries and at IRRI indicates that hybrid rice technology has the potential of increasing rice varietal yields by 15 - 20 % beyond those achievable with improved, semi dwarf, inbred varieties.

The recent progress in the breeding of Super hybrids in China by Prof. Yuan L.P. has achieved an average yield of 10.5 t/ha on commercial farms of 235,000 ha in 2000. (Yuan L.P. 2002). A three line super hybrid has posted new record yield of 17.95 t/ha in an experimental plot (800 m<sup>2</sup>) in Yunan Province in 2001.

Hybrid seed production must be based on male sterility systems. They are cytoplasmic (CMS), thermo-sensitive genic male sterility (TGMS) and photoperiod sensitive genic male sterility (PGMS). CMS system is predominantly used in commercial Chinese hybrids. Currently TGMS and PGMS systems are becoming more usable commercially.

The adoption and success of hybrid rice technology will depend largely on practical seed production technology; economical seed yields from hybrid rice plots; and efficient national seed production, processing, certification, and distribution programs in public and private sector. Hybrid seed production is complex and labour intensive and requires seed industry infrastructure to support it.

### **Commercialization of Hybrid Rice Technology**

China commercialized hybrid rice in the late 1970s. It is now a multi-billion dollar agribusiness in the World. It generated significant employment in the World today. According to Cheng et al. (2006) in China alone the area under hybrid rice increased from 0.14 million to more than 15 million ha in the recent years. This is more than 50% of the rice lands in China. The production by hybrid amount to 105 million tons annually at 7.0 t/ha. The remaining 50 percent area are planted with high yielding Varieties (HYVs) producing 81 million annually at 5.6 t/ha. The average hybrid rice in China yielded 20 % (1.4 t/ha) higher than the inbred HYVs (Yuan, L.P 2005).

Since 1990, other countries like Vietnam, India, Philippines, Bangladesh, Indonesia, Pakistan, Ecuador, Guinea and USA have also begun cultivation of hybrid rice. These countries have also made good progress in extending hybrid rice technology. Experimental trials and large-scale demonstrations in farmers' fields conducted in these countries showed that hybrid rice can significantly out yield local conventional varieties. For example, in the Philippines, with technical assistance from FAO, the International Rice Research Institute (IRRI) and the China National Hybrid Research and Development Center, hybrid rice was commercialized 2002. In particular, a super hybrid rice variety called SL-8 was developed in the Philippines; [6] it was planted to about 3 000 ha in 2003 and the average yield was 8.5 t /ha -more than double the country's average yield. On the basis of this achievement, the Government of the Philippines made an ambitious plan, with a goal of 3 million ha hybrid rice planted by 2007. The above facts clearly indicate that hybrid rice technology developed by China is also effective in greatly increasing rice yield worldwide.

Currently, about 600,000 ha were planted with hybrid rice in Vietnam. The yield of hybrid rice in Vietnam is 6.3 t/ha while that of the inbred varieties is 4.5 t/ha. Since the large scale cultivation of hybrid rice Vietnam is now the second largest rice-exporting country in Asia.

The International Rice Research Institute (IRRI) played a significant role in the commercialization of hybrid rice in tropical countries. Hybrid rice research began in 1979 at IRRI. Since then IRRI has evaluated and identified many elite hybrid and created a network with various tropical countries.

## **Cost of Production of Hybrid Seed**

The success of hybrid rice in China is attributed grossly to the efficient and economical hybrid seed production and distribution system organized by the State owned-seed industry.

## **Economic Viability of the Technology**

Hybrid rice seed production technology requires higher labour and is knowledge intensive. The risks involved are poor synchronization of parental lines and weather changes. Currently, hybrid rice seed production outside China is confined to Vietnam, India, USA and the Philippines.

## **The West Malaysian Experience**

Hybrid Rice research was initiated in 1984 in Malaysian Agriculture Research and Development Institute (MARDI) with the cooperation of International Rice Research Institute (IRRI). The system used was the three line system A, B and R lines. MARDI utilize imported Chinese cytotsterile lines.

MARDI evaluated hundreds of experimental hybrids both from China and IRRI with the intention of eventual release to the farmers. Two IRRI hybrids were identified but they could not be released due to the low out crossing potential of the cytoplasmic male sterile line (CMS) lines.

Further efforts to breed for locally adaptable CMS lines were attempted since most Chinese and IRRI hybrids mature too early (< 110 - 120 days) in Malaysia. The Chinese and IRRI CMS lines have unstable pollen sterility (the sterility changes from plant to plant) and low out crossing potential. Grain quality evaluation of the experimental hybrids indicated that the cooked rice is too hard for the Malaysian palate.

MARDI terminated Hybrid Rice Research in 1997. Direct seeding culture in West Malaysia requires very high seed rate (100 - 150 kg/ha). Imported hybrid rice seeds are very expensive. Production of hybrid seeds proved futile due to unstable pollen sterility and low out crossing potential. Seed set obtained in West Malaysia is very low about 15 - 20 %.

Hybrid rice if it were to be recommended in Malaysia will have to depend heavily on imported seeds from Philippines and India. Quarantine requirements must be taken into consideration for imports of large quantities of hybrid rice seeds.

## **Latest Developments in Malaysia**

A new effort to bring hybrid rice into Malaysia was led by Tan Sri Chua Hock Chin, a wealthy business tycoon. The company RB Biotech Sdn. Bhd spearheaded the development and commercialization of hybrid rice as part of the company's social responsibility programme. They set up a hybrid rice research centre at Kuala Rompin in Pahang. Currently there are five Chinese scientists working at the centre.

They were the same scientists who were involved in developing the SL8 variety in the Philippines. The company has already identified a variety for commercialization. It is a cross between a Japanese variety and Basmati rice from Pakistan. The company has named it 'Siraj' in honour of the sultan of Pahang.

MARDI is now working jointly with RB Biotech S B to evaluate these new hybrids in multilocal and yield trials and if the varieties are tolerant to major pests and diseases MARDI would endorse these varieties for large scale planting by December, 2008.

### **Sarawak's Experience**

The Research Branch of the Department of Agriculture evaluated the potentials of hybrid rice in Sarawak from 2002-2004. The lines were obtained mainly from China, Monsanto (Philippines) and SL Agritech (Philippines). The Chinese hybrids LP 44 - LP 53 were imported from Yuan Long-Ping High Technology Agriculture Company. Two Monsanto Hybrids C-05 H and C-24 H were given by Monsanto seed farms at General Santos (Philippines) and 13 Philippine hybrids were imported from SL Agritech farms at Los Banos (Philippines). The Chinese Hybrids mature between 95 - 98 days and recorded average yields ranging from 3.9 to 4.9 t/ha. Monsanto hybrids mature in 103 to 113 days and yields are vary average, about 4.1 to 5.2 t/ha. The hybrids from SL Agritech mature in 110 - 115 days and yield between 5.2 - 8.6 t/ha.

These hybrids have been evaluated for 3 seasons at ARC, Paya Paloh, Bundong Sian and Gedong. LP 44 was highly susceptible to bacterial leaf streak disease.

The management of Bundong Sian Padi Mini Estate in Bintangor has employed a Chinese hybrid rice breeder from Grand Agriseed Limited, Hunan. Currently, about 30 varieties of Chinese hybrids were evaluated. Efforts in seed production were not successful.

Many of the hybrids have been tested to be extremely susceptible to blast, bacterial leaf blight and bacterial leaf streak (BLS). Bacterial leaf streak is a seed borne disease and cannot be treated with chemicals.

In 2007, ARC and Bundong Sian will be evaluating Siraj; the variety developed by RB Biotech SB. Siraj will be planted in two types of soil, alluvial and acid sulphate.

### **Prospects and Challenges**

The prospects of hybrid rice are bright for Sarawak. The production technology in Sarawak is transplanting and seed requirement is about 15 - 25 kg/ha unlike West Malaysia where direct seeding is prevalent.

Super Hybrids which are currently being developed in China have vast potentials of achieving very much higher yields (17.97t/ha) which inbreds HYVs are not likely to achieve.

Singh (1988) in his paper 'Prospects for hybrid Rice in the Asian Pacific Region' stated that when planted under special condition, such as in saline-alkaline fields and in fields soaked with cold underground water or deep muddy soil, hybrid rice may out yield conventional varieties by 100 % or more. Sarawak has vast stretches of 'difficult' rice lands with saline and acid sulphate soils that may be able the benefit tremendously from this technology. The superior performance of hybrid rice is due largely to their vigorous root system and their wide adaptation across many topogeographical and soil types.

Hybrid rice adoption and production have their challenges. Hybrid seeds are expensive and new seeds have to be used every season. The shortage of seeds could have astronomical implications on the rice industry. Seeds should be produced locally and imports should be discouraged as diseases could be transmitted through seeds.

Hybrid rice research was terminated in West Malaysia in 1997. The two problems encountered in the CMS and hybrid seed production in West Malaysia are low out crossing potential and unstable pollen sterility. (Trinh 1994, Guok et al 1998) concluded that the production of hybrid seeds are therefore not feasible in Malaysia.

In 1994, Prof. Yuan expressed that the existing grain quality will become unacceptable as the living standards in China improves (Yuan, L.P. 1994). The grain quality of the hybrids has improved over the years. There are now many hybrids that are long grain and are of excellent quality. Siraj, developed by RB Biotech is a long grain fragrant and soft texture variety. This consideration is important as Malaysians generally prefer long grain and softer rice.

The future of hybrid rice in the world is bright. Although seed production of hybrid rice by MARDI was not successful, new approaches by RB Biotech S B have proven otherwise. Currently, the RB Biotech S B producing hybrid rice seeds in Rompin.

To conclude, the adoption and success of hybrid rice in Malaysia will be determined by the feasibility of seed production and seed industry infrastructure.

## **References:**

Guok, H.P., Azlan, S., Ku Yahaya, K.H. 1998. Developing hybrid rice technology in Malaysia. In: Virmani, SS, Sid, EA., Muralidharan, K., editors. Advances in hybrid rice technology. Proceedings of the 3<sup>rd</sup> International Symposium on Hybrid Rice. 14-16 Nov. 1996, Hyderabad, India, p. 353-358.

Guok, H. P. (Pers. Communication) Hybrid rice research in Malaysia.

Singh, R.B. 1988. Prospects for hybrid rice in the Asian-Pacific region. In: Hybrid rice. Proceedings of the International Symposium on Hybrid Rice, 6-10 Oct. 1986, p. 201-205. Manila (Philippines): International Rice Research Institute.

Trinh, T.T. 1994. FAO's contribution to hybrid rice development. In: Virmani, S.S., editor. Hybrid rice technology: new developments and future prospects, p. 267-274. Manila (Philippines): International Rice Research Institute.

Virmani, S. S , Mao C. X , Toledo , R. S and Hossain, M and Janaiah , A. (2001) Hybrid Rice Seed Production Technology and Its impact on Seed Industries and rural Employment Opportunities in Asia' presented at the International Workshop on Seed and Seedling Science and Technology at Taichung, Taiwan , Republic of China.

Yuan, L.P, Yang, Z. Y. and Yang, J. B. (1994) hybrid rice research in china. In: Hybrid Rice Technology new development and future prospects. Selected Papers from the International Rice Research Conference. P. 143-148.

Yuan, L. P. (2002) Recent progress in breeding super hybrid rice in China. Abstracts of the International Rice Congress, 16-20 September 2002, Beijing, China.

Yuan, L.P (2005) Hybrid rice technology for food security in the world. China National Hybrid Rice Research and Development Center, Hunan, China

Cheng Shihua, Cao Liyong, Zhai Huqu (2006). Rice production and development of hybrid rice in China. 2nd. International Rice Congress 9-13 October 2006, New Delhi, India.