Hybrid Rice in Asia

AN UNFOLDING THREAT

March 2000

ABOUT
THE
COVER

Jim Gibe, photographed in June 1998, is selecting a locally-adapted rice developed by MASIPAG farmers in the Philippines. The advent of commercial F1 rice hybrids directly threatens community breeding initiatives throughout Asia.

Hybrid Rice in Asia: An Unfolding Threat

was researched by Devlin Kuyek for a group of organisations and individuals cooperating in a joint project on current trends in agricultural R&D which will affect small farmers in Asia. The organisations participating in this research project are Biothai (Thailand), GRAIN, KMP (Philippines), MASIPAG (Philippines), PAN Indonesia, Philippine Greens and UBINIG (Bangladesh). Also participating in their individual capacities are Drs. Romeo Quijano (UP Manila, College of Medicine, Philippines) and Oscar B. Zamora (UP Los Baños, College of Agriculture, Philippines).

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INTRODUCTION

In the town of Malaybalay, on the southern island of Mindanao, in the Philippines, there is a sign on the highway that reads: *"Dole Philippines (Rice)"*. Dole, the giant US transnational corporation (TNC), operates vast hectares of pineapple plantations on the island, but until recently it has never shown any interest in rice. Neither had any other TNC operating in Mindanao. But on the same island, at a research facility outside of General Santos City, Cargill is also engaged in rice breeding. Why the sudden interest from TNCs in a seed market that has never attracted them before? The answer lies with recent developments in hybrid rice breeding.

Since it began thousands of years ago, farming has relied on the natural ability of plants to reproduce. We take it for granted, but the capacity of plants to produce seed is what feeds the world. However, historically it has not generated much profit – in order to make much money from a seed business you need to block the reproduction cycle. Hybridisation is a way of generating something akin to sterility in plants, such that the seeds from a hybrid crop cannot be advantageously saved for re-planting. Farmers who grow hybrids must buy new seed every year if they want high yields. This way, seed companies are assured of sales and profits.

Until recently, rice was never commercially hybridised. Because it is a self-pollinating crop, farmers could rely on their own resources to multiply, select and reproduce rice seeds. Consequently, there was no private seed industry activity in rice. All of this is changing now. And it will slowly, but surely, revolutionise rice farming in Asia.

What is hybrid rice?

Hybrids are produced by crossing two inbred – genetically fixed – varieties of a particular crop. Hybrids are special because they express what is called *"heterosis"* or hybrid vigor. The idea is that if you cross two parents which are genetically distant from each other, the offspring will be *"superior"*, particularly in terms of yield. However, the so-called heterosis effect disappears after the first (F1) generation, so it is pointless for farmers to save seeds produced from a hybrid crop. This makes it very profitable to go into the seed business, since farmers need to purchase new F1 seeds every season to get the heterosis effect (high yield) each time.

Rice is a mainly self-pollinated crop.[1] Each rice plant produces its own pollen which gets into an ovary and through fertilisation produces seed – what we eat as the rice grain. Rice has been a poor candidate for commercial hybridisation because you would have to find a way to sterilise some of the plants and then force them to cross with fertile plants. Going against nature can be hard work. For this reason, private industry never came into the rice seed business, and left farmers with their own seed supply. Only recently did this start to change.[2]

In 1970, Chinese researchers discovered a male sterile rice plant growing naturally within a population of wild rice (*Oryza sativa f. spontanea*) on Hainan Island. This plant had a particular cytoplasm – the material surrounding the cell nucleus – that induces male sterility through interaction with the nucleus. The plant was named *"wild rice with abortive pollen"* or WA for short. Scientists in China then began crossing WA with

[1] Rice can also cross-pollinate, naturally. However, this doesn't occur very often. In cultivated rice, the highest outcrossing rate observed is 6.8% while the average is around 5%. In wild rice, however, the outcrossing rate can be up to 100%. (S.S. Virmani, "Heterosis and Hybrid Rice Breeding", *Monographs on Theoretical and Applied Genetics* #22, Springer-Verlag, Berlin, 1994, p. 79.)

other rice varieties to determine whether this male sterility could be passed on to subsequent generations. Those that came out male sterile, called maintainer lines, were then repeatedly backcrossed until a stable sterile plant was achieved. This plant is called a *"cytoplasmic male sterile"* or CMS line. CMS lines form one of the parental lines for producing hybrid rice seeds. The other is known as the restorer line, as it restores fertility to the CMS line when it is crossed. The seeds from this cross are the F1 hybrid seeds, which is what farmers can then sow. The plants grown from F1 seeds show hybrid vigour. The next generation (F2) will normally not perform as well.

The CMS system is known as the *three-line system* since it requires three lines of rice: a CMS line, a maintainer line, and a restorer line. This system is what is being used in every country working on hybrid rice at present. However, it has several drawbacks. It is complicated, there are very few CMS lines and scientists are having a hard time identifying good maintainer and restorer lines.[3] For example, no effective restorer lines have been identified for *japonica* rice, which is cultivated in temperate zones. Similarly, scientists have only found a few varieties with male sterility-inducing cytoplasm, such as WA. None are as effective as WA, and WA continues to account for over 90% of all the hybrid rice varieties produced commercially in China alone.[4]

Researchers are now experimenting with new methods of hybrid rice production. One is called *"environment-sensitive genetic male sterility"*, which uses either photoperiod-sensitive genetic male sterility (PGMS) or thermo-sensitive genetic male sterility (TGMS). PGMS lines are sterile lines that regain fertility with daylight fluctuations. Therefore, they can only be used in temperate zones. TGMS lines regain fertility when the temperature fluctuates, which means they can be used in the highlands of the tropics. These methods are known as *two-line systems* since they do not require maintainer lines and any fertile line can be used as a pollen parent. Proponents maintain that this offers a wider choice of parental lines, but both PGMS and TGMS suffer from similar limitations to the CMS lines. Sources of PGMS and TGMS are exceedingly rare and by 1994, only 12 had been identified.[5]

There is still another horizon, which the Chinese call the *one-line system*. This refers to the long-term goal of transferring apomixis into rice, in this case hybrid rice. Apomixis is the capacity of a plant to reproduce asexually. Apomictic plants develop seeds, but without the merger of male and female reproductive cells. So the seeds are clones of a single parent plant. Apomixis is common in weeds but rare in crop plants. It doesn't exist in the *Oryza* genus but it does exist in *Pennisetum* and scientists have been hoping to transfer the genes for apomixis from pearl millet.

Other methods of inducing sterility in rice are genetic engineering, for example the SeedLink system[6], and chemical approaches using gametocides.

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2 Much of the following information in this box is derived from S.S. Virmani, "Hybrid Rice", *Advances in Agronomy*, Vol. 57, Academic Press, Inc, 1996, pp. 377-462.

3 For example, there is no effective restorer for *japonica* rice, which is the rice type grown in temperate zones.

4 S.S. Virmani, "Hybrid Rice", *op cit.*, p. 395.

5 *Ibid.*, p. 399.

6 Plant Genetic Systems, a biotech company in Belgium, developed the SeedLink system which involves a gene isolated from the tobacco plant, TA 29. The gene, which has been patented, is being transferred into rice to make it male sterile. PGS has since been bought by Aventis (Hoechst/Rhone-Poulenc), the largest pesticide company in the world.

1. DRIVING FORCES

Rice breeding has been the affair of farmers in Asia for thousands of years. In the process of collecting, selecting, exchanging, conserving and experimenting with rice plants, they have come up with well over 100,000 varieties with different characteristics. By the 1950s, white-coated laboratory scientists were getting in on the act. Chinese researchers were the first to change the architecture of the ordinary rice plant, around 1955, by systematically incorporating a semi-dwarfing gene (*sd-1*) from a specimen found in Taiwan. Traditional varieties are often tall and if you apply nitrogen fertiliser to boost their yield, they topple over. The *sd-1* gene produced medium-height rices that responded very well to chemical fertiliser. Thus, yields could shoot up. China lost no time in massively producing semi-dwarf rices, as did the International Rice Research Institute (IRRI) in Los Baños, the Philippines.

IRRI was set up in 1959 by the Ford and Rockefeller Foundations of the United States. Their plan was to organise a team of top-notch scientists, build an international laboratory and provide excellent conditions for these researchers to increase rice production in Asia, with the goal of fending off social unrest. In 1966, their big breakthrough came: IR8 was released. IR8, like its Chinese counterparts, was a semi-dwarf rice; and it responded well to intensive production practices, such as those used in the United States. It spread rapidly throughout Asia, earning the nickname *"miracle rice"*. For indeed, farmers who adopted the whole technology package for which IR8 was designed (irrigation and chemical inputs), saw their yields increase. Since then, IRRI has been breeding new rices adapted to the pest and disease problems that the Green Revolution farming practices, and the genetic erosion caused by widespread adoption of a few IRRI varieties, brought on.

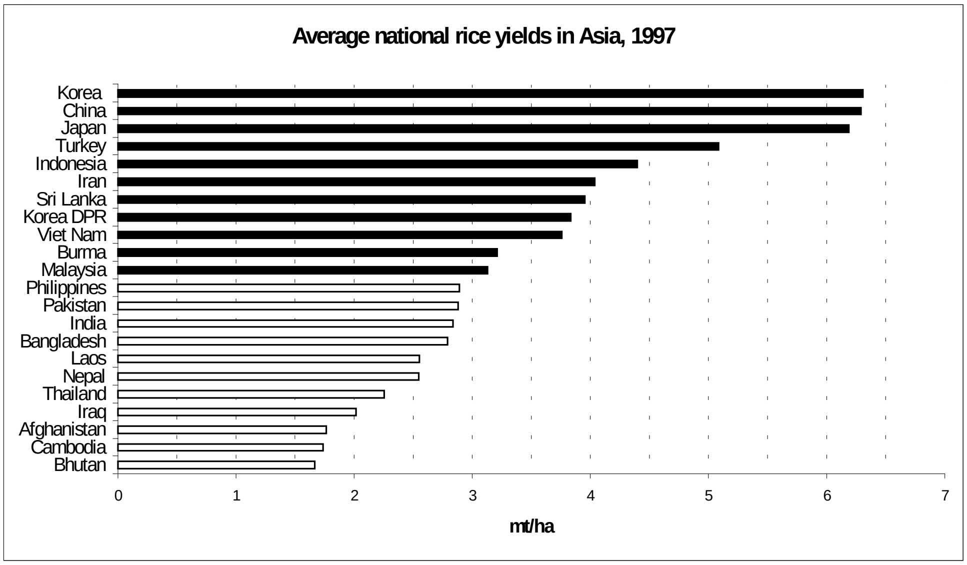
> *So far only hybrid rice has demonstrated the capacity to break the yield ceiling established by IR8 and other high yielding varieties.*
>
> – FAO, undated

IR8's *"genetic potential"* – the yield it can produce under ideal conditions – has never been surpassed by subsequent modern rices. On average, the best varieties churn out 10 mt/ha on research stations.[7] In reality farmers get three, six, sometimes up to eight tonnes (see Figure 1). This means, over time, that the yield *"ceiling"* in rice is stuck. Asian governments started complaining about this in the late 1980s and by now everyone is talking about the need to break the yield barrier. One route IRRI adopted, in classic miracle-maker style, was to try to come up with a so-called *"Super Rice"* or 15-tonner. This project implies a radical restructuring of the rice plant, once again. But IRRI has not yet succeeded.[8] The other route is hybridising rice, which IRRI hopes will produce 13 mt/ha. Either way, the objective is the same: instead of bridging the gap between the so-called yield ceiling and actual yields on the farmers' fields, the choice is to raise the yield ceiling. And China, once again, is out ahead.

[7] In fact, after 80+ consecutive croppings of IR8 at IRRI, the miracle rice's yield is noticeably declining, no matter how much extra inputs are applied. The reason? IRRI doesn't know, but the best guess is micronutrient depletion of soils when repeatedly stressed by Green Revolution production methods.

[8] In the early 1990s, IRRI announced that a 15-tonner would be released by 2000. Now the plan to achieve a 12-tonner, instead, by 2004.

Figure 1



Source: International Rice Commission, Country Rice Facts, FAO, December 1999

This [hybrid rice] technology is not for farmers who are still struggling at the level of 2 or 3 tons [per hectare].

– S.S. Virmani, IRRI, 1998

2. A RICE REVOLUTION UNFOLDS IN CHINA

Hybrid rice was introduced commercially in China in 1976. Today, it grows on approximately 50 percent of China's total rice area, or 15-16 million hectares. The conquest of hybrid rice is a source of immense pride for many Chinese authorities. Recent reports even suggest that China's "father of hybrid rice", scientist Yuan Long Ping, has developed one variety that yields 17 tonnes per hectare.[9]

Most available estimates suggest that China's hybrid rice yields on average 15-20 percent more than the high-yielding inbred varieties. The country is currently aiming to bring this up to 40 percent. Official sources claim that hybrid rice helped increase China's rice production by 220 million tonnes from 1976 to 1992, but the extent of the contribution made by the seeds themselves is debatable. Most studies of crop yield increases in China since the 1950s stress the overwhelming role of fertilizer and irrigation.[10]

China's hybrid varieties are almost entirely *indica* varieties planted early in the year. The early *indica* crop is China's lowest quality crop and consumers do not like the hybrid varieties. In fact, much of the crop is purchased by the state and a large part of the harvest is used in state programs to feed the urban poor, stored in the country's rice stocks, or used as animal feed. Besides its low quality, China's hybrid rice has poor disease and pest resistance. The severe limits on the possible germplasm that can be incorporated into a hybrid system have prevented researchers in and outside of China from breeding successfully for specific resistance to diseases and pests.

In 1988, researchers in China reported that incidence of stem borer, white back plant hopper, leaf roller, bacterial blight, sheath blight, and virus diseases were more frequent on hybrid rice than on inbred rice. They also found that local outbreaks of diseases such as downey mildew, false smut, and

[9] "China research centre breeding super hybrid rice," *Asia Pulse*, 14 September 1999.
[10] See Gerhard K. Heilig, "Can China Feed Itself? A System for Evaluation of Policy Options", International Institute for Applied Systems Analysis, Laxenburg, 1999. http://www.iiasa.ac.at/Research/LUC/ChinaFood/argu/impact/imp_81.htm

kernel smut occur frequently on hybrid rice.[11] It is not surprising, then, that pesticide use increases with hybrid rice. A survey of 500 households in Hunan, China, in 1988 found that any yield increase resulting from the use of hybrids was partly offset by increased chemical inputs.[12] One study of early season rice in Hunan in 1990 – 15 years after the introduction of hybrids – showed no statistically significant difference in yield between hybrid rice and conventional inbred rice, despite the fact that hybrid rice required 31% more pesticides and 43% more fertilizer.[13]

A further limitation to hybrid rice production in China is the breeding process itself. Hybrid rice seed production is a labor- and skill-intensive activity, and the yields are low at around 2 mt/ha.[14] Hybrid seed production is therefore extremely expensive and relies on heavy public subsidies.[15] Since the introduction of hybrid rice, the difference between the farm-gate price for rice and the retail price has widened. By the end of the 1980s, more than 20 percent of the government's total revenue was spent financing the gap.[16] Subsidies have also gone directly to the seed industry for production of hybrid rice seed. In the 1990s, those subsidies were lifted temporarily, and the area under hybrid rice quickly decreased by 2 million hectares (30 percent).[17] This acreage could slip in the future as China moves to meet its requirements to join the World Trade Organization (WTO) and dismantles state subisidies.

According to Yuan Long Ping, China has already reached the yield plateau for hybrid rice.[18] Further advances for the near future will reportedly be squeezed from the two-line system. But there, the blockage point for its widespread national use is the lack of genetic diversity.[19] With the government agenda myopically focused on increasing yields, something will certainly be done.

3. PROPOGATING THE HYBRID LINE

Intrigued by the practical application of hybrid technologies in China, a few key agencies have formed a consortium to ensure that the rest of Asia tries to reap benefits from hybrid rice. "Development and Use of Hybrid Rice Outside of China" is an international project that brings together IRRI, the Food and Agriculture Organization (FAO) of the United Nations, and the Asia Pacific Seeds Association (APSA), a group of all the major seed companies operating in Asia. The sole funder for the project is the Asian Development Bank (ADB). From 1998-2000 the ADB will provide a total of US$1.5 million towards the project. The project targets Bangladesh, India, Indonesia, the Philippines, Sri Lanka and Vietnam, and involves China itself since last January. The greatest constraint to the project is the limited number of parental lines and their narrow genetic base.[20] The market goals of the project are shown in Table 1.

[11] T.W. Mew *et al.*, *op cit.*, pp. 189-200.
[12] J.Y. Lin, "Hybrid rice innovations in China: A study of market demand-induced technological innovation in a centrally-planned economy", Peking University, 1990.
[13] *Ibid.*
[14] S.S. Virmani and Ish Kumar, "Hybrid rice seed in Asia-Pacific", *Asian Seed and Planting Materials*, Vol. 4, No. 5, APSA, Bangkok, October 1997, p.11.
[15] *Ibid.*
[16] Frederick W. Crook, "Policy Critical to Future of China's Rice Market", *Rice Yearbook 1996*, United States Department of Agriculture, Washington DC, 6 December 1996.
[17] S.S. Virmani, "Hybrid Rice", *op cit.*, p. 441.
[18] "Hybrid rice breeding in China", *Advances in Hybrid Rice Technology*, IRRI, 1998, p.29.
[19] Lu Xinggui *et al.*, "Advances in two-line breeding", *Idem.*, p. 96.
[20] Xiao C. Liu *et al.*, "Improving parental lines to increase efficiency of hybrid rice breeding: some new approaches", *Advances in Hybrid Rice Technology*, *op cit.*, p. 102.

Table 1: Area cultivated with hybrid rice outside of China[21]

Country	Area cultivated with hybrid rice in 1997 (ha)	Anticipated area in hybrid rice in 2000 (ha)
India	120,000	1,000,000
Vietnam	100,000	500,000
Philippines	500	100,000
Bangladesh	-	150,000
Burma	-	150,000
Indonesia	-	50,000
Sri Lanka	-	20,000

IRRI's role in the project is to develop good parental materials and viable seed production technologies. China's breeding lines have not performed well in other countries and various quarters complain of restrictions on accessing Chinese materials.[22] To fill the gap, IRRI has developed almost one hundred CMS lines, of which two – IR58025A and IR62829A – have become the "stars", as they supposedly give good combining results. Released in 1991, these two lines currently, which are genetically similar[23], form the basis of most hybrid rices being tested or grown in tropical Asia outside China. They are already being commercially exploited in India, the Philippines and Vietnam.[24]

APSA's role in the project is to identify the constraints to large-scale private sector production of hybrid rice: mainly infrastructure and subsidies. Nevertheless, members of the association – which include Monsanto, Novartis, DuPont, Aventis and Rice Tec – are eagerly putting IRRI's material to work. The ADB, with its powerful influence over government policies in the region, will fine-tune the policy tools needed to support the hybrid rice industry. Finally, FAO's role in the project is to provide consulting services to strengthen the hybrid seed industry.[25]

Biodiversity or bust

The biodiversity of rice is under threat from decades of genetic erosion. The Green Revolution, led by IRRI's high-yielding varieties (HYVs), displaced farmers' traditional varieties and their wild relatives on a massive scale. The present state of biological diversity in Asia's paddy fields is alarming. By the mid-1980s just two HYVs occupied 98 percent of the entire rice growing area of the Philippines.[26] In Thailand and Burma, five varieties occupy nearly 40 percent of the total rice area, while in Pakistan the top five occupy 80 percent. In Cambodia, a single IRRI variety accounts for 84 percent of the country's dry season crop. Such widespread uniformity leaves Asia's rice crops in an extremely vulnerable position.

Hybrid rice presents an even more serious threat. It is an extremely uniform crop and the varieties available in Asia rely almost exclusively on a single wild relative and only a handful of different maintainer or restorer

21 Taken from S.S. Virmani, "Advances in the Development and Use of Hybrid Rice Technology for Increasing Global Rice Production," presented at the First National Workshop for Strengthening National Capacity for Hybrid Rice Development and Use, 5-6 August 1998, Muñoz, Philippines.

22 S.S. Virmani, "Hybrid rice research and development in the tropics", in *Advances in Hybrid Rice Technology*, IRRI, 1998, p. 35.

23 B. Suprihatno and dan Satoto, "Research and development for hybrid rice technology in Indonesia", *idem.*, p.414.

24 *Ibid.*, pp. 41-42.

25 "Involve pvt sector seed industry to boost hybrid rice production", *The Daily Star*, Bangladesh, 2 September 1998.

26 S.S. Virmani, "Hybrid Rice", *op. cit.*, p.7.

lines. In China, where hybrid rice comprises about 50% of rice lands, there has been a 46-fold reduction in local varieties being grown over the last 40 years.[27]

A more subtle means of genetic erosion is likely to occur as the private sector takes over the role of the public sector in developing new materials. Seed companies tend to focus on a limited number of varieties with broad application, tending to ignore local conditions. The most effective breeders for particular on-farm conditions are the farmers, but they are excluded from the breeding process altogether. Also, the private sector does not engage in genetic conservation and tends to use a more narrow range of germplasm in developing new products.

A particularly troubling threat from hybrid rice is cytoplasmic uniformity. The cytoplasm surrounds the nucleus of a cell. Although the nucleus contains most of the genetic information of a cell, the cytoplasm carries extra-nuclear genes that can provide disease and pest resistance. Widespread cytoplasmic uniformity can lead to massive crop failures. In 1970, a fungus wiped out 15 percent of the US corn crop, costing farmers millions of dollars, because almost the entire crop was derived from an identical source of susceptible cytoplasm.[28]

Most high yielding ricevarieties grown in Asia are derived from one Chinese maternal parent, *Cina*, whose single form of cytoplasm is nearly ubiquitous today. In 1980, *Cina* was the maternal parent of 74 percent of the "post-IR8" rice varieties in Indonesia, 75 percent in Sri Lanka, 62 percent in Bangladesh, more than 50 percent in the Philippines, and 25 percent in Thailand. By 1994, a full 91% of all post-IR8 rice varieties officially released in the Philippines could be traced back to *Cina*.[29] These figures are cause for serious concern. In rice breeding, the maternal parent contributes about 60% of the genetic material found in the ensuing progeny, largely through the cytoplasm.

IRRI is aware of all these dangers. Dr. S.S. Virmani, head of IRRI's hybrid rice program, recognises that, *"Continuous use of a CMS system risks potential genetic vulnerability of the hybrids to a biological stress."*[30] Nevertheless, most hybrids released in Asia outside of China are based on two CMS lines from IRRI. In terms of the cytoplasmic uniformity of these hybrids, the problem is quite real. *"WA is the only cytoplasm that has been found to be commercially useable up to now,"* says Dr. Ilyas Ahmed, also from IRRI.[31]

4. THE PRIVATE SECTOR: POSTURING FOR THE PAYOFF

At this point, the bulk of the work in developing hybrid rice outside of China remains with IRRI and the national systems. Seed production is costly and time-consuming, and early efforts by private companies have been largely unsuccessful. For example, Cargill and Ring Around Products purchased exclusive licenses for Chinese hybrid varieties outside of China in the 1980s but neither company could produce marketable seeds and both backed out of the agreements by 1992. However,

[27] Pei Yanlong, W. Lianzheng, Gao Li Zhi, and Hong De Yuan, "What is happening to the diversity of rice genetic resources in China," in T. Partap and B. Sthapit (eds), *Managing Agrobiodiversity - Farmers' Changing Perspectives and Institutional responses in the Hindu Kush-Himalayan Region*, 1998. Retrieved from the World Wide Web at http://www.icimod.org.sg/focus/biodiversiyt/agribiodiv5.htm on 15 December 1999.

[28] Donald Plucknett *et al.*, *Gene Banks and the World's Food*, Princeton University Press, NJ, 1987, p 14.

[29] J.C. de Leon, *Genetic Relationships Among Philippine-Bred Rice Varieties as Determined by Pedigree- and Morphology-Based Measures*, MS thesis (plant breeding), UPLB, October 1994, p. 45; and Hargrove, T.R. *et al.*, "Ancestry of Improved Cultivars of Asian Rice" in *Crop Science*, Volume 20, p 721.

[30] S.S. Virmani, "Hybrid Rice", *op cit.*, p. 398.

[31] Interview with Dr M. Ilyas Ahmed, Project Scientist, Plant Breeding, Genetics and Biochemistry Division, International Rice Research Institute, at IRRI, Los Banos, the Philippines, 17 November 1999.

as research into hybrid rice advances, the role of the private sector will expand. There are already signs that this is occurring.

Nearly all the seed companies conducting research and development of hybrid rice in Asia, with the exception of China and Vietnam, are owned by or linked to the world's largest seed companies (Table 2). Several of them already have commercial hybrid rice varieties on the market. In India, there are several local companies engaged in hybrid rice production, but the bulk of research and development is carried out by foreign corporations. Other private companies pursuing hybrid rice include RiceTec (USA), notorious for its patent on Basmati rice, and Granja 4 Irmaos, a Brazilian seed company recently purchased by Aventis.

Table 2: Agrochemical TNCs involved in the hybrid rice seed industry in Asia

Agrochemical TNC	World ranking	Agrochemical sales 1998 (USD billions)	Hybrid rice seed subsidiaries in Asia
Syngenta*	1	8	Ring Around Products (USA) joint venture with Mitsui (Japan)
Aventis	2	4.5	Hybrid Rice International (India)
Monsanto	3	4	Agroseed/Cargill Seeds (Philippines). Mahyco and Maharashtra Hybrid Seed Company (India)
DuPont	4	3.2	SPIC-PHI (India)
Marubeni	n.a.	n.a.	Joint venture with the Burmese government

* Syngenta is the recently announced merger of the agrochemical divisions of Novartis and AstraZeneca.

Certain developments can be anticipated as hybrid rice and the role of private seed companies expand. To maximise profits, private companies focus on a small number of varieties that can perform reasonably well over the largest possible area. Not surprisingly, the private sector is looking to IRRI and China for germplasm for its hybrids.[32] According to the Philippine Rice Research Institute (PhilRice), *"As much as possible, the private sector will try to use the same CMS."* The development of new CMS lines is a costly and lengthy process and it is apparently up to the public sector to "help" the private sector diversify its material.[33] Likewise, extremely important multidisciplinary research based on molecular biology, cytology, genetics, plant physiology and ecophysiology does not generate short-term returns, and, as such, will not be taken up by private sector research and development.[34] With more private sector involvement, the limitations of hybrid rice, in terms of pest and disease resistance, are unlikely to be addressed except, of course, through agrochemicals and genetic engineering.

It is significant that the TNCs which dominate private hybrid rice research and development are also the world's biggest pesticide and biotechnology companies. It was the high-yielding varieties of the Green Revolution that ushered pest and disease problems onto the farms of Asia, and pesticides soon followed. The high susceptibility of hybrid rice to disease is likely to foster further dependence on agrochemicals.[35] In this sense, hybrid rice presents a tremendous opportunity for pesticide compa-

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[32] Interview with Dr Ahmed, *op cit.*

[33] Interview with Dr. Leocadio Sebastian, Deputy Executive Director of the Philippine Rice Research Institute, at PhilRice, Los Baños, Philippines, 18 November 1999.

[34] Jean-Pierre Berlan *et al.*, "Génoplante: A strategic error," *Seedling*, Vol. 16, No. 3, September 1999, p.19.

[35] Interview with Dr Ahmed, *op.cit.*

nies, which are reeling from market saturation in the North and anxious to expand sales in Asia. For similar reasons, it creates new markets for their proprietary genes.

A springboard to GE rice

A number of factors makes hybrid rice a prime candidate for genetic engineering. The first relates to the breeding process. In order to produce F1 hybrid seed, breeders must work with lines that incorporate particular characteristics – most are associated with male sterility, but other characteristics, such as out-crossing potential, are also important. These demands impose significant limitations on the possible varieties that the breeder can use. As a result, breeders have been unable to breed commercial hybrid varieties with resistance to disease and pests comparable to conventional varieties. For instance, while hybrids developed at PhilRice are very susceptible to bacterial blight, PhilRice's conventional varieties have few problems with the disease.[36] It goes without saying that the transgenic rice varieties with disease and pest resistance that PhilRice plans to field-test in the near future are primarily destined for the institution's hybrid rice program. Furthermore, genetic engineering is already being used within the hybrid rice breeding process itself. Aventis owns a technology for creating male sterility though genetic engineering, which it uses to develop commercial varieties of transgenic oilseed rape and which it intends to use for rice. Likewise, Chinese researchers are genetically engineering rice for herbicide tolerance in order to facilitate the selection process in hybrid rice production.[37]

A second link between hybrid rice and biotechnology relates to the economic context. The seed industry is going through an incredible period of consolidation. Seeds were once an industry of low returns and long-term investments that few companies were interested in, especially for crops such as rice, where seeds are mostly farm-saved. But, with global acceptance of industrial property rights on plants and the advent of genetic engineering, the former tycoons of the immensely profitable agrochemical industry have sat down to feast. Within a few short years, the largest pesticide companies in the world have taken oligopoly positions in most seed sectors – particularly those dominated by hybrids. Between 1997-1999, transactions by these companies in the seed industry topped US$18 billion.[38] Furthermore, these companies control around 80 percent of all research and development in agriculture biotechnology. The reason is simple: genetically engineered traits can increase the value of a seed market by upwards of fifty percent, making even small markets, such as hybrid rice, attractive investments.[39] In India alone, Monsanto and friends are eyeing additional sales of $450-500 million per year thanks to hybrid rice seed.[40]

Hybrid rice may also increase pressure for deregulation of international trade in rice seeds. This has already begun to happen. Hybrid rice seed developed by seed companies in India is already exported to Bangladesh and Burma. Such cross-border flows will discourage the development of national industries, but transnational seed companies, with a presence in many countries, can achieve substantial cost savings through economies of scale by concentrating breeding in one or two

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[36] Interview with Dr. Sebastian, *op cit.*; and interview with Dr. Casiana Vera-Cruz, IRRI Plant Pathologist, at IRRI, Los Baños, Philippines, 9 March 2000.

[37] D.N. Huang *et al.* at the China National Rice Research Institute, "Breakthrough in purity of hybrid rice seed," in *Asian Seed and Planting Material*, Vol. 5, No. 4, APSA, Bangkok, August 1998, p.10.

[38] Manfred Kern, Aventis Crop Science, Box 3: Commercial Applications of Biotechnology in Crop Agriculture, in G.J. Presley, "Agriculture Biotechnology and the Poor: Promethean Science" Retrieved from the World Wide Web http://www.cgiar.org/biotech/rep0100/contents.htm on 3 March 2000.

[39] G. Traxler, "Assessing the prospects for the transfer of genetically modified crop varieties to developing countries", *AgBioForum*, 2(3&4), 1999, pp. 198-202. Retrieved from the World Wide Web http://www.agbioforum.org on 3 March 2000.

[40] S.S. Virmani and Ish Kumar, "Hybrid rice seed in Asia-Pacific", *Asian Seed and Plant Materials*, APSA, Bangkok, Vol. 4, No. 5, October 1997, p. 11.

countries. The Asia-Pacific Seed Association has raised international trade of hybrid rice seed as a special concern. It claims:

> An unmistakable trend in the global seed market is the merging of multinational corporations so that all aspects of modern seed technology are covered in a vertically integrated fashion from R&D in biotechnology to hybrid seed distribution. The scope of R&D in seed technology is towards regional markets, in contrast to country-specific conditions. While it is in the interest of individual countries to build internal capacities in developing hybrid rice technology, and to generate hybrid lines that are adapted to and perform exceptionally well under local conditions, the member countries should never adopt a national policy of barring the importation and use of hybrid lines developed from another member country for reasons other than not meeting internationally accepted sanitary and phytosanitary standards.[41]

In other words, according to APSA, Asian countries should not take a national approach to research but be porous to varieties marketed by TNCs. This would clearly increase genetic uniformity in the region, increasing susceptibility to disease and pest outbreaks, and wiping out local varieties. It could also facilitate the movement of seed production to areas where labor is cheap and environmental regulations are lax, such as Burma.

Hybrid rice is also bound to increase pressure for strong intellectual property rights (IPR) regimes in Asia. At present, there is little pressure for IPR on hybrid rice because few companies are carrying out research and development for their own hybrid lines. All of the parent lines come from public sector research, and private companies can protect the hybrid seed varieties they sell by not revealing which parental lines from the public pool they used. This may not last long. First, as the big companies develop more hybrid lines, they will want to squeeze out smaller competitors with state sanctioned monopoly rights, ostensibly to protect their investments. Companies such as Indo-American Hybrid in India and Rice Tec in the US have already sought patents on hybrid rice varieties, even though public parental lines were used in the crosses. Second, as most of the companies are also involved in biotechnology, they will want to incorporate patented genes into their hybrid rice varieties, and will demand heavy legal protection. This trend is embedded in the requirements of the WTO agreement on intellectual property, known as TRIPS, which Asian countries have for the most part yet to implement.[42] Given that major rice research institutions, such as IRRI, have begun incorporating patented genes into their breeding programs, such a development will give a clear advantage to the giant TNCs that dominate patents in plant biotechnology. After all, just four companies own nearly one-third of the plant biotech patents in the world.[43]

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[41] "APSA Identifies Hybrid Rice Constraints" in *Asian Seed & Planting Material*, Vol. 6, No. 4, APSA, Bangkok, August 1999. Emphasis added.

[42] See GRAIN, "For a full review of TRIPS 27.3(b). An update on where developing countries stand with the push to patent life at WTO," GRAIN, Barcelona, March 2000, on the World Wide Web http://www.grain.org/publications/reports/tripsfeb00.htm

[43] According to Derwent Biotechnology Abstracts up to December 1999, Syngenta, DuPont-Pioneer, Monsanto and Aventis are the direct owners of 28% of the world's patents in plant biotechnology.

5. HYBRID "STRAINS" AT THE NATIONAL LEVEL

The forced flood of hybrid rice in Bangladesh

In 1998, the Bangladesh National Seed Board broke long-standing policy and announced that private companies could import 2,200 metric tonnes of seed for cultivation in the coming *boro* (dry) season. Bangladesh was hit by a prolonged flood from July to September that year, and the imported seeds were part of the government's post-flood rehabilitation program.

Immediately following the Seed Board's decision, Advanced Chemical Industries, Ltd (ACI) of Bangladesh announced plans to import hybrid rice from India. The variety it imported was Aalok 6201 from Hybrid Rice International, a subsidiary of Proagro, which is owned by Aventis, the world's largest agrochemical company. ACI was not acting alone. IRRI supported the introduction of hybrid seed through training workshops, and private companies and seeds were sold by ACI and a large micro-credit agency in the area, the Bangladesh Rural Advancement Committee (BRAC). As Farhad Mazhar of UBINIG recalls, *"Immediately after the flood, BRAC aggressively promoted Aalok 6201 . . . Farmers had to accept credit and pay very high interest, but at the same time had to accept the proprietary technology of ACI."*[44] In fact, most farmers were not even told that they would be unable to save seed from the hybrids in the following year. They were only informed after the harvest by a threatening advertisement in one of the daily papers warning them not to save seed.[45]

The introduction of hybrid seed in Bangladesh is intimately connected to micro-credit. Mazhar maintains that, *"Micro-credit is the only way that hybrid seed can be sold in countries like Bangladesh."* About half of Bangladesh's 120 million people are bound by some form of micro-credit financing, and big agencies like BRAC are the engines for a cash economy in the countryside.[46] Consequently, the seed industry has formed a direct alliance with BRAC to coerce farmers into planting hybrid seed. For instance, when Gulab Jan, a resident of Delduar, approached BRAC for a 3,000 taka (USD 60) loan to repair her leaky house, she was given 2,700 taka in cash and the rest in hybrid seeds. *"When I protested that I had no land to cultivate it on, they asked me to find someone who has – but nobody wants hybrid seeds around me,"* she told Inter Press Service.

Farmers in Bangladesh, already suffering from the flood, were used as test cases for hybrid rice production. The results are not impressive: Aalok 6201, despite its high cost and chemical input requirements, was struck by blast infection and gave little to no yield advantage over the popular inbred varieties BR 28 and BR 29.[47] UBINIG has investigated every success story reported in the papers and found each of them to be untrue. Farmers have reacted with anger to the forced introduction of hybrid rice. They have held demonstrations and rallies throughout the country and one farmer is even taking BRAC to court over the agency's promotion of hybrid rice. Even Bangladesh's rice scientists are resisting the incursions of hybrid rice.

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[44] Farhad Mazhar, "Destructive consequences of 'controlling plant gene expression' or 'Terminator Technology' for food security and biodiversity", Paper presented at the Pre-SBSST-4 Consultative Workshop, 25 May 1999, Bangladesh.

[45] Interview with Farhad Mazhar, 26 January 2000.

[46] Dev Raj, "Hybrids hit by farmer resistance," *IPS Bulletin*, Inter Press Service, 19 January 1999.

[47] Interview with Dr Ahmed, *op cit.*; and "Hybrid Paddy Cultivation Starts in Bangladesh", *The Daily Ittefaq*, Bangladesh, 17 October 1998.

Winners and losers in the Philippines

All modern agricultural technologies, whether they involve genetic engineering or hybridization, seem to be promoted as means of feeding growing populations. Threats are often made that if these technologies are not adopted, people will starve and wars will break out over resources, especially in developing countries. Within this framework, "supply" comes off as the most pressing problem and yields turn into the singular target of agricultural development. But yield is an eminently political issue. For instance, it is often said in the local newspapers that the Philippines only needs to increase its average rice production by 1 mt/ha to be self-sufficient. The question, then, becomes how to achieve this. According to IRRI data, the maximum attainable yield in the Philippines in the years 1991-1993 was 6.30 mt/ha while the average yield stood at 2.05 mt/ha.[48] In pursuing higher yields, do you focus on bridging that gap or on seeking higher maximum yields assuming the average will "catch up"?

Small farmers in the Philippines are unable to "catch up" because of tremendous obstacles. For instance, in Laguna, where IRRI and PhilRice are located, nearly all farmers are tenant farmers and on average between 60-70 percent of a farmer's harvest is collected by the landlord as payment for rent. A farmer's monthly earnings barely cover half of the month's living expenses and farmers are forced into what is commonly called *"double farming":* children apply for work as domestic helpers and the parents seek income from the informal economy or as construction workers while waiting for harvests. Furthermore, the landlord is the creditor, the miller, and the farmer's only connection to the market all at once, and there are no limits to how much he or she can exploit the farmer.[49]

There are many intermediaries that rice must go through from the farmer to the consumer in the Philippines: middlemen, landlords, wholesalers, small wholesaler-retailers, millers, retailers, and the National Food Authority (NFA). The entire process, however, is dominated by a rice cartel called the Big Seven. While the NFA is responsible for the regulation and control of agricultural commodities, in reality it is the Big Seven that controls the distribution of rice and sets the prices.[50] Over the last four years, the NFA has only procured an average of 5 percent of total rice production when it would need to buy at least 24 percent of the national harvest in order to influence the market.[51] Without effective government intervention, the cartel has squeezed both farmers and consumers. Since 1993, the wholesale price of rice has shot up from 10.78 pesos/kg to 16.94 pesos/kg, while the actual price paid to many farmers in the countryside hovers at just over 5 pesos/kg – slightly below the cost of production.[52]

According to Dr. Sebastian of PhilRice, depressed and unstable prices for rice are the greatest constraints on improved rice productivity. When farmers know in advance that they will receive

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[48] See "Asia: Supply, Demand and Production Potential of Rice in Asia", Riceweb, IRRI, on the World Wide Web http://www.cgiar.org/irri/Riceweb/g_overasia.htm and Ros B. Guzman, "The GATT Agreement on Agriculture: Final Blow to Philippine Farms?" *IBON Special Release*, No. 46, Manila, July 1999.

[49] Interview with Laguna peasant organization representatives Dodoy Julian (PUMALAG/KASAMA-TK), Fitz Faigmani (Southern Tagalog Agenda for Genuine Development Alternatives), Jerry Mangubat (KASAMA-TK), and Butch Espere (KMP Information Desk), Los Baños, Philippines, 18 November 1999.

[50] Danilo Arana Arao, "Impact of the GATT on Philippine Rice and Corn", Paper presented at the Asia-Pacific Research Network Conference on Trade Liberalization, Manila, 29-30 July 1999.

[51] Doris Dumlao, "Malacañang okays NFA reforms", *Philippine Daily Inquirer*, Manila, 29 October 1999.

[52] Statistics on wholesale price from D. Arao and information on countryside prices from conversation with Rafael Mariano, Chairman, Peasant Movement of the Philippines (KMP), Manila, 17 November 1999.

decent prices for their crops, they can make confident assessments of how much they should invest in new technologies, such as hybrids. It is ironic, then, that the ADB, which is bankrolling the development of hybrid rice in Asia, has made both low NFA rice prices *and* the privatisation of the NFA a condition of its loans to the Philippines government.

ADB's actions actually make perfect sense when hybrid rice is seen as a tool for the corporate take-over of agriculture. Liberalisation will force farmers in the Philippines into competition with cheap subsidised imports when they are already struggling to make a profit. Between 1996 and 1998, the retail price for imported rice was nearly half that of local rice.[53] Such competition places enormous pressure on small farmers and will force them either off their lands to make way for large landholdings or into contractual growing arrangements with local or transnational companies. In the latter instance, the TNCs feed on the vulnerable situation of the farmer to coerce him or her into contractual arrangements, where a price, albeit a low one, is guaranteed. As part of the contract, the farmer receives credit from the company to buy its seeds and the chemical inputs, and has to bear the risks of crop failure. But, as long as rice can be saved from year to year, the companies cannot generate the dependence that makes contract farming so profitable for them. In this sense, hybrid rice and liberalisation go hand-in-hand in the extension of corporate control over rice.

At present, three hybrid rice varieties have been released in the Philippines: two under the name of PhilRice (although at least one was bred by IRRI[54]) and one from Agroseed (i.e. Cargill, i.e. Monsanto). Although the yield data is highly contradictory[55], and all three hybrids carry susceptibilities to pests and diseases, there is a battalion of government subsidies involved in their promotion. These props will need to be cut if the Philippines continues on its course toward greater economic liberalisation, as required by the nation's financiers IMF and ADB, not to mention the country's commitments to WTO and ASEAN. Whether hybrid rice will become a viable option for Filipino farmers is hard to bet on.

Companies hungry for the action in India

Hybrid rice production and development began in India in 1990 when the Indian Council for Agriculture Research, with financial support from the United Nations Development Program, launched the National Research Network on Development and Use of Hybrid Rice technology at 12 sites across the country. Research and development was and continues to be led by the public sector, but the private sector is now taking a more active role. Currently, 16 seed companies are producing hybrid in the country, using eight hybrid lines. Hybrid rice is grown principally in Andhra Pradesh, Karnataka and Tamil Nadu.

The vast majority of these seed companies were established in the 1980s, when the government embarked on its major economic liberalisation programme. During those years, the government made

[53] Doris Arao., *op cit.*

[54] Dr. Virmani himself is the breeder of Magat, registered as RCB 26H. (*Advances and Challenges in Hybrid Rice Technology in the Philippines*, PhilRice, Muñoz, 1998, p. 98.)

[55] According to Dr. Sebastian of PhilRice, all three average 15% higher yields over the country's current inbreds in the national trials (personal communication, 14 March 2000). However, Mestizo, one of the PhilRice hybrids, gives a mere 7-10% yield gain over the best inbreds in Central Luzon, the nation's "rice bowl" (Tonette Orejas, "Central Luzon tries new rice hybrid", *Philippine Daily Inquirer*, 25 January 2000). And as recently as 1998, the pure-lines were still outyielding the hybrids in national trials (J.C. de Leon *et al.*, Hybrid rice in the Philippines: progress and prospects", *Advances in Hybrid Rice Technology, op cit.*, p. 351).

seeds of public-bred varieties available to the private sector for multiplication and distribution and it brought down restrictions on the importation of seeds. While the former change encouraged the growth of domestic seed companies, the latter brought the rapid entrance of large foreign seed companies. Today, most hybrid seed companies in India are either owned, in whole or in part, by foreign TNCs or closely allied to them. For instance, the principal producers of hybrid rice in India are Hybrid Rice International which is owned by Aventis, Mahyco which was bought by Monsanto, and Spic-PHI Biogene which is part of DuPont.

So far, hybrid rice has had limited impact in India. The cost of the seed is high (USD 2.40-3.00/kg), the yield advantage is a low 15 percent and the quality of the grain is poor enough to fetch 8 percent *below* the price of conventional rice on the market. Nevertheless, both government and industry are pushing hard for hybrid rice's "success". But already, social movements in India are developing a wide front of resistance to hybrid crops.[56] Their main concerns? The reliability of the material, the impact on genetic diversity, increased dependency of farmers on the industry and very pertinent questions about the motives of the private sector. Indian farmers have already experienced manipulation of seed prices and supplies, and know very well that the private companies invest in lucrative export crops, not poor peoples' crops.[57] So they have serious reservations about how farmers can benefit from hybrid rice.

Vietnam in the shadow of China?

Vietnam is taking a different route. In the production of hybrid rice, there is little differentiating the country from a Chinese province. Nearly all the seeds are imported from China, except for a Chinese-Vietnamese joint venture, and, as in China, the state is actively involved in production. The acreage sown to hybrid seed leapt from 100 ha in 1991 to 220,000 ha in 1999, with yields now at 6.3 mt/ha. In the next five years, one million hectares will be sown to hybrid rice – but only if the government keeps at it. To reach this target, *"The State is requested to give incentives to help scientific workers and farmers replace the traditional rice strains with hybrid rice."*[58] China is also needed. In 1995, China purchased Vietnam's entire low-quality hybrid surplus. In the ensuing years, China decreased its overall imports but one of the requirements for immersion into the world trade system governed by WTO is that China adopt import quotas for agriculture commodities, including rice. In all likelihood, much of that quota will be filled by low-quality rice from Vietnam. But there are certain obstacles to the production of hybrid rice in Vietnam. While hybrid rice grows relatively well in northern Vietname, it has failed in the south, where climatic conditions are more similar to Malaysia.

Uncertainty elsewhere

Around 1998-1999, the Malaysian Agriculture Research and Development Institution (MARDI) abandoned its attempts to develop hybrid rice in the country. According to MARDI rice breeder, Dr. Guok Hup Peng, hybrid rice failed in Malaysia and continued development was simply *"not worth it."* When MARDI tried to produce hybrids itself, the CMS lines were not stable and, as a result, there was a high proportion of self-seed from inbreeding. Seed yields were also very low and expensive to

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[56] Jeroen van Wijk, "Hybrids, bred for superior yields or for control?", *Biotechnology and Development Monitor*, No. 19, University of Amsterdam, June 1994.
[57] *Ibid.*
[58] Vietnam News Agency, "Hybrid Rice Acreage to be Expanded", Ha Noi, 16 November 1999.

produce. MARDI even tried imported hybrid seed from India, but that route, too, was besieged with problems.

Guok believes that weather is the main problem. Hybrid rice increases yields during cool seasons, which do not exist in the tropics. This means it will not do well in countries between 10 degrees latitude north and 10 degrees latitude south, such as Thailand, Cambodia, southern Vietnam, the Philippines and Indonesia. In India, hybrid rice production is confined to *"continental"* or northern areas with different climatic conditions from Southeast Asia, offering greater chance of success. Burma's climate may be suitable and foreign companies are already exporting hybrid rice seed to the country and have begun production.

Another major drawback to hybrid rice in Malaysia is the high seed cost. More than 80 percent of the rice area in Malaysia is direct seeded, and direct seeding requires a high volume of seed. The high cost of hybrid seed makes it impractical for direct seeded farms. The same is true for Thailand.

The Indonesian government shares a similar lack of enthusiasm, which is understandable. Most of the materials provided by IRRI just didn't perform well in Indonesia. Even one of IRRI's two "star" CMS lines segregated there, as in Malaysia, making it useless. Things have gone so poorly that in 1993, the government slashed its budget for pursuing hybrid rice.[59] Nevertheless, the private sector is bound to try to commercialise hybrid rice as soon as it can.

Thailand also appears to have little interest in hybrid rice. Although it is the world's biggest exporter of rice and has some of the lowest average national yields in Asia, the Thais have stayed out of the IRRI/ADB/FAO program and done relatively little at home to make hybrids a viable national option. There is talk of hybridising jasmine rice[60], Thailand's finest, but that would no doubt meet stiff opposition from poor farmers if they cannot reproduce the seed.

6. ASSESSING WHAT HYBRID RICE MEANS FOR ASIA

The yield gamble raises doubts

In their promotion of hybrid rice, proponents such as IRRI, FAO and industry roll out Malthusian images of hungry masses scrambling for food produced on less and less land. They side-step the issues of equity and redistribution, and claim that the only solution is technological, in this case a hybrid fix. Aside from the political questions this approach raises, the assumption that hybrid rice is the best way to increase yields certainly needs to be challenged. IRRI's studies indicate that several of the hybrids that it has developed increase yields by 15-20 percent. And yet, after 20 years of research, only three rice hybrids have been able to out-yield the best inbred by that margin in IRRI's host country. Perhaps part of the problem is the theory of heterosis itself.

[59] B. Suprihatno and dan Satoto, "Research and development for hybrid rice technology in Indonesia", in *Advances in Hybrid Rice Technology, op cit.*, p. 418.

[60] P. Pongtongkam *et al.*, "Anther culture of hybrid rice (Khao Dawk Mali 105/Skybonnet)", *Kasetsart Journal*, 29(2):158-166, Bangkok, April/June 1995.

Heterosis as a myth

Scientists have yet to explain how heterosis works and some, such as Jean-Pierre Berlan, of the Institut National de la Recherche Agronomique in France, believe that it is actually a myth. Berlan maintains that while rice may demonstrate some hybrid vigor, *"The real phenomenon is inbreeding depression."*[61] Hybrids appear to produce high yields because they out-yield the parental lines they were crossed from by a significant margin. However, Berlan argues that yields from the parental lines are depressed by the many backcrosses that breeders must make for them to be stable. Thus, hybridisation does not necessarily produce *"improved varieties";* it only improves upon the parental lines.

While the scientific theory of heterosis remains unexplained, the economic impact does not. The costs of hybrid rice seeds are very high: up to 15 times higher than seeds from elite inbred varieties.[62] The major problem is that seed yields are very low, making seed production costly. Farmers who buy these expensive seeds season after season face the added burden of low market prices for their harvest. The selling price for hybrid rice is significantly lower than the price of regular rice in both India and China, two countries with the most experience.

Some farmers call hybridisation *"the scam of the century."*[63] Why? If you compare the trajectory taken by two contrasting crops in a country like France – wheat, which is self-pollinated like rice, and corn, which cross-pollinates and can easily be hybridized – the picture is shocking. Wheat and corn were both grown from local populations until hybrid corn took off 40 years ago. In those 40 years, the public research sector continued to work on improving non-hybrid wheat, while the private sector took control of corn breeding, which became entirely devoted to hybrids. The result for the farmer is clear. Wheat yields between the early 1960s and the late 1990s were multiplied by 2.2 whereas the corn yields barely doubled. At the end of the four decades, wheat seed prices were three times the cost of the grain whereas corn seed prices were 30 times the cost of the grain. For hybrids, then, the yield increase has been lower but the price increase has been spectacular. This is why farmers feel short-changed by hybrization: the science is *"not explained and unexplainable"*,[64] the yield increases have not matched those of the inbred crops and yet the seed prices have shot through the roof. Research to improve the performance of open-pollinated corn varieties – which the private sector is not interested in, since farmers can save the seed – might have provided much more sustainable options than hybrids. Will the same happen in rice?

There are other, more sustainable, less costly, and less culturally destructive means for increasing yields. Hybrids work against efforts to harness local resources internal to the farm for increased yields and total system productivity. Since hybrids produce more with more (chemical inputs), they will also further strain the sustainability of the soils and the surrounding ecosystems and injure the health of farm families. That is why they are inefficient.[65] IRRI's own research confirms massive degradation of farmlands from its Green Revolution varieties; hybrids will only intensify the process.

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[61] Personal communication, 26 January 2000.
[62] S.S. Virmani, "Hybrid Rice", *op. cit.*, p. 403.
[63] Jacques Laigneau, "La guerre des semences fermières", Coordination Rurale, Auch, décembre 1999.
[64] *Ibid.*
[65] The inefficiencies of high external input agriculture run deep. "In the Philippines it has been estimated that moving from the traditional to the modern system of rice production implied an increase of 3000% in energy inputs, to get a 116% increase in yield (a 26:1 ratio)." Filemon Torres *et al.*, "Agriculture in the Early XXI Century", retrieved from the World Wide Web http://www.fao.org/nars/gfar2000/download/agri21.doc on 16 March 2000.

Hybrid rice is not for poor farmers

The decision to pursue hybrid rice is not simply a decision to increase production. Fundamentally, it is a decision to try to boost the productivity of a particular group of farmers who can sustain a private seed industry. The most glaring drawback with hybrid rice is that it is simply not intended for small farmers, whose production systems need the most attention. Dr. Virmani of IRRI is blunt about this. *"This technology is not for farmers who are still struggling at the level of 2 or 3 tons."*[66] Looking back at Figure 1 on current rice yields, that's an awful lot of farmers in Asia.

Small farmers struggling with abysmal market prices and exorbitant rent cannot possibly afford to purchase expensive hybrid seeds year after year. The problem is openly admitted by IRRI: *"The cost of hybrid seed, being 10-15 times higher than that of ordinary seeds of rice, discourages poor farmers from taking advantage of hybrid technology."*[67] It is only "appropriate", or intended, for wealthy farmers on the irrigated lowlands.

In those communities where hybrid rice is introduced, whether through sales agents, government extension services, micro-credit agencies or contract farming, there are bound to be significant social impacts, particularly where management practices have to change radically. Hybrid rice does away with the culture of exchanging and sharing seed. One example of what this means comes from the village of Anibongon in Sta. Rita on the Philippine island of Samar. Barangay Chair, or village leader, Heracleo Cajefe recently established a demonstration hybrid rice field after he attended a training on hybrid rice seed production. Local farmers interested in bartering seeds from his impressive crop were taken aback when heturned them down. Cajefe knew that farmers can't reuse seed from a hybrid crop, but the villagers accused him of being *"greedy"* because of his sudden unwillingness to share rice seeds.[68]

In acknowledging the problem of sterility, hybrid rice enthusiasts hold out the vague promise of apomictic rice. Theoretically, apomixis would allow farmers to save hybrid seeds from year to year, since successive generations would be exact clones of the previous generation. For IRRI, *"to make hybrids affordable, even to resource-poor farmers, it is essential to develop apomictic varieties."*[69] But, while plans are underway to rapidly expand the acreage planted with rice hybrids, *"there is no success so far [with apomixis] and it is still a long term goal of research."*[70] Apomixis may be a long-term goal, but it raises some immediate concerns. The benefit of apomixis will be determined by whether it is in the public or the private domain. If the seed industry or its allies are able to patent the technology, it will effectively rule out the supposed benefits to small farmers. A cursory look at patents covering apomixis in rice reveals a few active players. Maxell Hybrids, an American company, has a patent lodged in Europe, the US and China on apomictic rice. For its part, the US Army deposited an international patent application in 1998, already approved in the US, on transferring apomixis from pearl millet into rice[71], a goal which IRRI shares but may now not be able to realise.

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[67] S.S. Virmani, "Hybrid Rice", *op cit.*, p. 403.

[68] Olive Rose Matchoc, "Farmer shares knowledge with community," *PhilRice Newsletter,* Vol. 12, No. 2, April-June 1999, p 13.

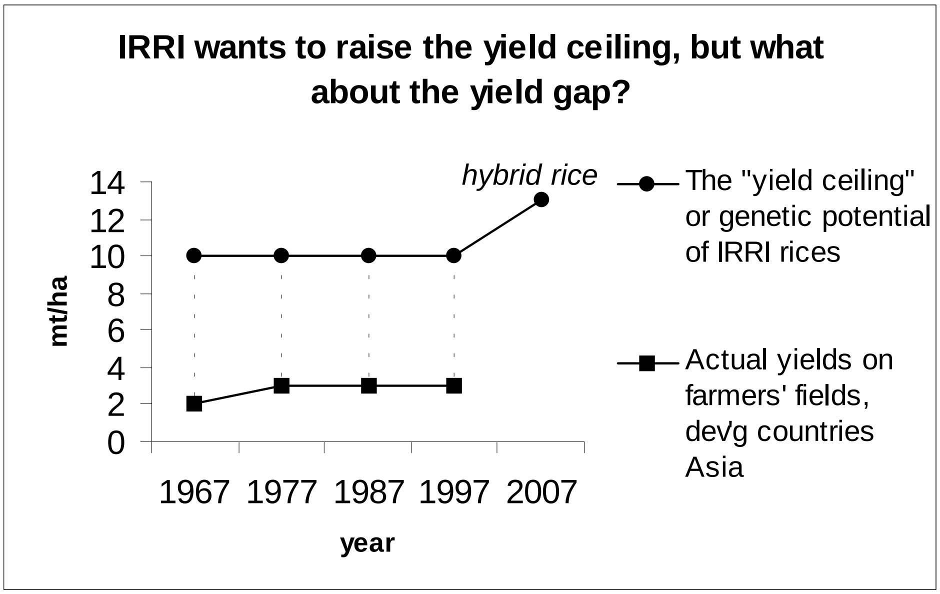
[69] S.S. Virmani and Ish Kumar, *op cit.*, p.12.

[70] S.S. Virmani, personal communication, 23 January 2000.

[71] WO9710704 and US5811636.

Governments which compose the International Rice Commission at FAO have clearly stated that, *"Although there is an urgent need to increase yield potential of rice in areas where yields are already high, there is a more urgent need to increase yields in areas where farmers yields are far inferior to potential yields."* FAO itself argues that if the current yield gap can be bridged, global rice output would increase by 25 percent.[72] (See Figure 2.) By the same token, post-harvest losses in rice often surpass 20% whereas improved irrigation could increase global output by vast amounts. So why hybrid rice?

Figure 2



An open door for the industry

Hybrid rice is not about feeding people. First, most people don't even want to eat the rice because it tastes bad. Second, it will only exacerbate problems of distribution and poverty by favoring wealthy farmers. And finally, hybridisation is a very inefficient and limited way to increase supply. As pointed out by one hybrid rice proponent, Dr. Durga B Chaudhary of Plantek, Inc., *"Hybrid technology, as such, addresses our concern for food security [only] very modestly."*[73] Beneath the rhetoric, the real motivation behind the development of hybrid rice is to create a rice seed industry as a motor for the deeper industrialization of rice farming. The point is hammered home by Romualdas G. Vildzius of Brigada Berde, an NGO funded by Shell oil company in the Philippines: *"That really to us is the major incentive – to gently, slowly bring [the farmers] around to a more corporate farming viewpoint."*[74]

Appropriately, the model for the proponents of hybrid rice is the American corn seed industry. According to Dr. Virmani, *"Rice hybrids can have the same catalytic effect on the development of the [Asia] region's seed industry that hybrid corn had on the seed industry development in North America."*[75] For corn, the *"catalytic effect"* has sent droves of farmers off the land and produced a

[72] "Involve pvt sector seed industry to boost hybrid rice production", *The Daily Star,* Bangladesh, 20 September 1998.
[73] Vote of Thanks, *Advances and Challenges in Hybrid Rice Technology in the Philippines, op cit.*, p. 156.
[74] General discussion on technology promotion, *idem.*, p. 119.
[75] S.S. Virmani, "Hybrid Rice", *op cit.*, p.443.

seed industry where two companies, Monsanto and DuPont (through Pioneer) own or significantly influence 90 percent of the American seed corn market.[76]

These companies are now set to take over rice. In February 2000, Monsanto, the second largest seed company in the world, enthusiastically announced that it and other seed giants were *"pouring"* money into rice research because of the growing potential for hybrid rice. The company explains, *"With the advent of adequate intellectual property protection in several countries, private sector investment in rice has dramatically increased, particularly in the seed industry."*[77] As intellectual property regimes – be they patent or plant variety protection laws – allow companies to charge an additional 10-30% over the cost of the seed, in the form of a royalties or license payments, the income opportunities for the industry are attractive indeed.

CONCLUSION

The stubborn equation of hybrid rice with progress must be questioned. First, the technology has demonstrated minimal impact to improve yields. Significant increases in yield are rare, if not site-specific; there are no cost-effective methods for seed production; and studies show that hybrids require more pesticides because they are more susceptible to disease and pests. The technology is also severely limited by the fact that it is impractical for most tropical countries in Asia. Yet, IRRI, multilateral agencies and public research institutions throughout the region continue to devote substantial amounts of money and time towards the development of hybrid rice. Fundamentally, the decision to pursue hybrid technology is a entirely political one. In the words of Jean-Pierre Berlan,

> [Hybridization is] a political choice because it creates a privilege for seedmen who retain the exclusive right to reproduce and multiply a plant or an animal. The most fundamental property of plants and animals, and indeed of all living organisms is to re-produce and multiply. Any restriction to this property, by whatever means (hybrids, terminator, verminator, patents, administrative means) is a social waste. When will breeders and scientists finally understand that to improve plants and animals, it is certainly easier and more efficient to rely on this fundamental property rather than to oppose it?[78]

No matter how secluded the laboratory where the technology is produced, hybrid rice cannot succeed in isolation from global developments. It is clear that this technology will dramatically draw in the private sector. The heavyweights are already putting their investments down, aided and abetted by IRRI, FAO and the ADB. What this will mean for small farmers and consumers will be determined by the leverage of the industry in the economic landscape. Today, the seed industry is controlled by a handful of agrochemical corporations that are all actively pursuing genetic engineering to increase dependence on their proprietary chemicals and genes. Nearly 80 percent of the world's farmlands sown to transgenic crops today is devoted to plants that have been designed to be sprayed with herbicides. A similar pattern is bound to emerge with hybrid rice, as the big life science companies own patents for herbicide-tolerant rice, which is already being field-tested. But more ominously, given the technical constraints in developing hybrid rice for the tropics, genetic engineering will play a pivotal role. This is not only true of combining abilities but of the need for pest and disease

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[76] Marvin Hayenga, "Structural change in the biotech seed and chemical industry complex," *AgBio Forum*, 1(2), 43-55 (1998). Retrieved from the World Wide Web http://www.agbioforum.missouri.edu

[77] American Seed Trade Association, *ASTA News Update*, 18 February 2000.

[78] Personal communication, 26 January 2000.

resistance. The industry's growing control over proprietary technology in this area – topped by the big question mark on who will own apomixis – is close to an assurance that just a few corporations are likely reap whatever is to be gained from hybrid rice.

The development of hybrid rice in Asia is reaching a critical stage. If the technology can be made to work well enough in farmers' fields, the private sector will take over the seed market and breeding – and most of the options that could be left to farmers. Should the public sector – including IRRI – make sure this happens, which is what seems to be happening now? Or should it vigorously turn its back and address the more basic problems of the poor?