Blast, biotech and big business

IMPLICATIONS OF CORPORATE STRATEGIES ON RICE RESEARCH IN ASIA

AUGUST 2000

http://www.grain.org/publications/reports/blast.htm

Rice blast is a problem almost everywhere that rice is grown. This fungal disease *(see box)* is estimated to cause production losses of US$55 million each year in South and Southeast Asia. The losses are even higher in East Asia and other more temperate rice-growing regions around the world.[1] Blast is gaining interest among agricultural biotechnology companies because of the potential genetic engineering offers to generate dual profits for their chemical and seed departments. The rice blast problem and industry's approaches to dealing with it provide a clear example of how corporate research and development (R&D) strategies are diverging further and further from the needs and means of farmers, particularly in the poorer countries of South and Southeast Asia.

What is blast?

The rice blast disease is caused by the fungus *Pyricularia grisea*, which, in its sexual state, is known as *Magnaporthe grisea*. The disease can strike all aerial parts of the plant. Most infections occur on the leaves, causing diamond-shaped lesions with a gray or white center to appear, or on the panicles, which turn white and die before being filled with grain.[2] *P. grisea* is highly specific to rice, although certain strains that don't attack rice can harm weeds in the rice field. Once on a rice plant, the fungus rapidly produces thousands of spores, which are carried readily through the air, by wind or rain, onto neighboring plants.[3]

Blast was first reported in Asia more than three centuries ago and is now present in over 85 countries. It is highly adaptable to environmental conditions and can be found in irrigated lowland, rain-fed upland, or deepwater rice fields.[4] Jim Correll, a scientist from the University of Arkansas, who has worked on blast for years, speculates that the disease originated in Asia, where rice itself originated, and was spread throughout the rest of the world by the exchange of seeds. Blast can survive on seeds and can easily move over borders if proper safety checks are not in place. In 1996 in California, USA, despite the enforcement of strict safety measures to prevent the entry of blast, the disease managed to find its way into the state's paddy fields for the first time.[5]

While it is present nearly everywhere rice is grown, blast is more of a problem in the temperate flooded and tropical upland cropping systems, marked by cooler climates.[6] Rainy periods or periods of high humidity also favor the disease. Certain cultural practices encourage blast: excessive use of nitrogen (through chemical fertilizers) increases susceptibility of rice to the fungus, as does inadequate spacing (often practiced under rice intensification programs).

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[1] Robert W. Herdt, "Research Priorities for Rice Biotechnology," in *Rice Biotechnology*, G.S. Khush and G.H. Toenniessen (eds.), Alden Press Ltd., London, 1991, pp. 35-37.

[2] S.C. Scardaci et al., "Rice Blast: A New Disease in California," Agronomy Fact Sheet Series 1997-2, Department of Agronomy and Range Science, University of California, Davis, retrieved from http://agronomy.ucdavis.edu/uccerice/AFS/agfs0297.htm, on 18 May 2000.

[3] Rick Cartwright and Fleet Lee, "Management of Sheath Blight and Blast in Arkansas," retrieved from http://ipm.uaex.edu/diseases/Rice/Shethblt/sheathBL.htm, on 18 May 2000.

[4] K. Manibhushan Rao, *Rice Blast Disease*, Daya Publishing House, Delhi, India, 1994, pp.1-2.

[5] Personal communication with Dr Jim Correll, University of Arkansas, 6 June 2000.

Blasting a moving target

Chemicals are somewhat effective against blast, and a number of the major pesticide manufacturers market commercial pesticides targeted at the disease. Breeders have also spent years looking for resistant varieties of rice that farmers have selected over generations. They have not only collected many traditional rice varieties that are resistant to blast, but have also identified a number of rice genes that they believe are responsible for the resistance. Neither chemicals nor breeding provide a totally effective approach, however. Due to the pathogen's ability to rapidly adapt, crops remain vulnerable.

These conditions make blast a very attractive candidate for genetic engineering in corporate labs. Genetic engineering offers the perfect means for pesticide companies to protect and expand their earnings, as the limitations of – and the risks involved with – chemically-intensive agriculture to control the disease become increasingly obvious. Not surprisingly, a number of giants in the industry, with vested interests in pesticides and seeds, are eagerly pouring millions of dollars into producing rice seed-chemical packages to "manage" the disease. In the long-term, the technology for blast will only form one small component of a much larger corporate program for disease management that will have deep implications for nearly all sectors of agricultural production.

Yet genetic engineering will not provide poor rice farmers in Asia a solution to the blast problem. Looking at it from their situation, the GE approach is impractical, expensive and unwarranted, as there are much more affordable and effective ways to control the disease. In this sense, there is a fundamental conflict within agricultural research and development – between an agenda that caters to the needs of industry and one that addresses the needs of resource-poor farmers, the bulk of Asia's population.

In most rice growing areas of South and Southeast Asia, blast remains less of a problem than some other diseases, such as tungro and bacterial blight. Few studies have been done to examine the intensity of the problem.[7] The Rockefeller Foundation found in 1991 that 3.8% of the rice area in Southeast Asia was affected by blast, causing yield losses of 3.1 kg/ha resulting in production losses valued at US$14.3 million. In South Asia, yield losses were almost three times as high: rates climbed to 8.8 kg/ha at a cost of US$40.9 million.[8] More recent figures from Pesticides Action Network (PAN) Indonesia show that during the October 1999 - March 2000 planting season, rice blast infested some 15,000 hectares across 60% of the provinces in the Indonesian archipelago.[9]

Over in the Philippines, a nationwide survey conducted in 1996 among an extensive sampling of farmers by the National Crop Protection Center showed that blast is not much of a problem. The

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[6] S.C. Scardaci et al., "Rice Blast: A New Disease in California," Agronomy Fact Sheet Series 1997-2, Department of Agronomy and Range Science, University of California, Davis, retrieved from http://agronomy.ucdavis.edu/uccerice/AFS/agfs0297.htm, on 18 May 2000.

[7] P.S. Teng, C.Q. Torres, F.L. Nuque, and S.B. Calvero, "Current knowledge on crop losses in tropical rice", *Crop Assessment in Rice*, IRRI, 1990, p. 39.

[8] Robert W. Herdt, "Research Priorities for Rice Biotechnology", in *Rice Biotechnology*, G.S. Khush and G.H. Toenissen (eds.), Alden Press Ltd., London, 1991.

[9] Personal communication, 24 July 2000.

more important problems for the farmers were stem borer, brown plant hopper, green leafhopper, rice bug, leaf folder, golden apple snail and tungro.[10] Another recent study *(see box)* demonstrated that, in a country like the Philippines, diseases such as blast are among the least significant factors affecting the country's rice supply, even if they are seen as hot targets for genetic engineering.

Nice landing, wrong airport

A study conducted by the Swiss Federal Institute of Technology in Zurich (ETH), in cooperation with the University of the Philippines Los Baños, investigated the perception of problems affecting the Philippine rice economy and the potential of genetic engineering to solve them.[11] The questionnaire was answered by 65 respondents from 46 organizations, all active in the field of genetic engineering: NGOs, including consumer organizations (28%); government institutions (23%); business sector (12%); international research institution, the International Rice Research Institute (IRRI, 9%); academia (8%); legislators (6%); media (6%); international foundations (5%); international NGOs (3%). Respondents were asked to assess the importance of the problems of the Philippine rice economy according to a ranking of 1 (least important) to 5 (most important). The same scale was used to assess the potential of genetic engineering to solve the problems.

The most serious problems affecting rice production were assessed to be market conditions, lack of irrigation facilities, inadequacy of post harvest facilities, indebtedness due to high input costs, weak support services, typhoon, inefficient transport network and unequal land distribution. Meanwhile the potential of genetic engineering for solving production problems was rated highest in controlling plant diseases and pest infestation, improving food quality, reduced use of pesticides, stabilizing yields and developing drought tolerance.

The study showed that there is a serious mismatch between the perceived problems affecting rice production and the potential of genetic engineering to solve them. The potential of genetic engineering is highest for problems that are perceived to be least important, such as pest infestation. The result of the study stresses the fact that the amount of money and time being invested in biotechnology is disproportionate to its importance, at least in the case of rice in the Philippines.

Table 1. Perception on the most important problems of the Philippine rice economy and the potential of genetic engineering (GE) for solving them.

Problem	Most Important Problems of the Philippine Rice Economy		Potential of GE for Solving the Problem	
	(Rank)	(Score)	(Rank)	(Score)
Market conditions	1	4.5	16	1.9
Irrigation facilities	2	4.5	13	2.1
Post harvest facilities	3	4.3	12	2.2
Indebtedness (from high input costs)	4	4.3	11	2.3
Weak support services	5	4.2	17	1.8
Typhoon	6	4.2	15	2.0
Inefficient transport network	7	4.2	18	1.8
Unequal land distribution	8	4.1	19	1.4

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[10] P.A. Javier, R.A. Zorilla and F.V. Bariuan, *National Pest Survey*, monograph, 1996, NCPC, College of Agriculture, Los Baños, chpt. 3, p. 6.

[11] Philippe Aerni (1998), *Public Acceptance of Genetically Engineered Food in Developing Countries: The Case of Transgenic Rice in the Philippines*. Zurich, Switzerland: IAW/ETH Zurich Publications.

Drought	9	4.1	6	3.4
High use of pesticides	10	4.0	4	3.6
Reduced soil fertility	11	4.0	8	3.3
Little investment in R&D	12	3.9	10	2.3
Pest infestation	13	3.9	2	3.8
Fluctuating yield	14	3.9	5	3.6
Flood	15	3.8	9	2.8
Soil erosion	16	3.8	14	2.1
Plant diseases	17	3.7	1	4.0
Small numbers of variety	18	3.3	7	3.0
Poor eating quality	19	3.3	3	3.8

Source: Philippe Aerni, "Public Acceptance of Genetically Engineered Food in Developing Countries: The Case of Transgenic Rice in the Philippines", IAW/ETH Zurich Publications, 1998.

Pesticide pitfalls and breeders' block

For industry, meanwhile, blast is a big money spinner. It is one of the few crop diseases that justifies the development of single-target fungicides: the Japanese market alone for blast fungicides is estimated at US$400 million per year.[12] However, chemical fungicides present hazards to human health and the environment, and farmers in Asia are already rejecting them in favor of more sustainable approaches. Some researchers are looking into alternative, non-chemical fungicides. Studies suggest that there are many substances naturally occurring in plants that are toxic to the blast fungus, although, to date, there has been little research and development in this area. Biological agents, such as micro-organisms or botanical pesticides, are also available to control the disease.[13] But the Asian market is still studded with a range of chemical weapons, some of them so hazardous that their sales are restricted by several governments.

Despite the sales figures, the blast fungicide market is still compromised. Blast fungicides are expensive products for a generally insolvent set of customers – Asian rice farmers. Fungicides for blast typically consume 6%-50% of total crop protection costs.[14] The big Japanese market is only sustained by the highest agricultural subsidies (70%) in the world.[15] Syngenta's Quadris (azoxystrobin), which was not developed specifically for blast but for a range of diseases on a

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[12] Jim Bonman, "Rice Disease Management: Industry approaches and perspectives," ICPP98 Paper Number 3.6.7S, retrieved from http://www.bspp.org.uk/icpp98/abstracts/3.6/7S.html, on 11 October 1999.

[13] K. Manibhushan Rao, *Rice Blast Disease*, Daya Publishing House, Delhi, India, 1994, pp. 1-2. Rao mentions *Gliocladium* and *Trichoderma* as well as botanical treatments based on henna, betal leaf and lecithin soybean seeds. Research by A.A. Sy, L. Albertini and M. Moletti documents the effectiveness of *Chaetomium globosum* ("Biological Control of Rice Leaf Blast", in R.S. Zeigler, S.A. Leong and P.S. Teng (eds), *Rice Blast Disease*, CABI/IRRI, 1994, pp. 521-527).

[14] Fernando Correa-Victoria et al., "Know Your Enemy: A novel strategy to develop durable resistance to rice blast fungus through understanding the genetic structure of the pathogen population," CIAT, 1992.

[15] Data compiled from USDA-ERS and Oskam (1995) in J. Pretty et al, "Pesticides in World Agriculture: Causes, Consequences, and Alternative Courses," in William Vorley and Dennis Keeney (eds), *Bugs in the System: Redesigning the pesticide industry for sustainable agriculture*, Earthscan, London, 1998.

number of crops, costs upwards of US$25-30 per acre for each application: well out of reach of most producers in Asia.[16]

A second limitation stems from the fungicides themselves. When the fungicides are used intensively, they place enormous selection pressure on blast, and the pathogen rapidly develops resistance. Given that it costs up to US$100 million to develop a new fungicide and bring it to market, companies are rarely willing to develop new products when resistance to the older brands develops. The only fungicide recently introduced specifically for blast is carpropomid, which was introduced as Win in 1998 by Bayer's Japanese subsidiary Nihon Bayer Agrochem. Farmers are therefore left with the choice of using fungicides in moderation, which leaves the crop vulnerable to blast, or beginning a cycle of heavier and heavier dosages of chemicals.

Neither option is appropriate. Not only is chemical protection too expensive but, even in moderation, there are indirect costs from the use of fungicides to the health of the farming family and the surrounding ecosystem, which put great strain on the family's limited resources. As these problems have become more widely recognized, the international agriculture research institutions have responded by shifting their focus to breeding. Breeding efforts, however, have also been quite limited in their success. Blast is highly variable, especially under intensive, large scale monoculture conditions, and breeders simply can't keep up with it. As reported by CIAT, *"New blast strains mutate rapidly, rendering resistant varieties susceptible within 2 or 3 years of release – sometimes, even before the breeding lines reach the farm."*[17] The result is a never-ending race for breeders to keep ahead of the disease with new varieties.

Fungicides and breeding have both been deployed against blast within a specific model of intensive rice production that was promoted by the 'Green Revolution' – chemical-greedy varieties, uniform crops and irrigated lands. Fungicides and breeding can be used to patch up problems, such as blast, that intensified under the Green Revolution, without requiring any fundamental change in direction. However, neither fungicides nor breeding are capable of sustaining the fight against blast. Some believe that genetic engineering can resolve this dilemma.

The hunt for durable resistance

Scientists are now trying to use genetic engineering to create what is called *"durable resistance"* – plant resistance to disease that lasts for long periods of time. The initial idea was to isolate the genes responsible for blast among resistant plant varieties, clone these genes, and then incorporate them into susceptible high-yielding varieties. In theory, the transgenic varieties could benefit the pesticides industry, seed breeders, and farmers. Farmers would get an effective form of long-term protection against blast; breeders would have the tools required to produce varieties with durable resistance; and the pesticides industry would capture new markets by

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[16] "Quadris Zaps Rice Diseases", *Progressive Farmer*, October 1998, retrieved from http://www.progressivefarmer.com/issue/1098/rice/, 18 May 2000. One acre is equal to 0.405 hectares.

[17] Fernando Correa-Victoria et al., "Know Your Enemy: A novel strategy to develop durable resistance to rice blast fungus through understanding the genetic structure of the pathogen population," CIAT, 1992.

shifting product development from chemicals to seeds. In practice, however, genetic engineering is unlikely to fulfil these expectations.

Durable resistance to blast is elusive. Dr Sally Leong, a leading molecular biologist conducting research on rice blast at the University of Wisconsin, is sceptical that it will ever be attained. *"It's a never-ending cycle,"* she says. *"Durable resistance is a formidable problem."*[18] Dr Chris Lamb, another leading scientist studying plant disease resistance at the John Innes Centre in the UK, seems to agree. *"Plant diseases are moving targets,"* he says. *"Like death and taxes, they will always be with us."*[19]

The fundamental problem, as those studying biotechnology have quickly learned, is that there is no simple mechanism controlling disease resistance in plants. Those scientists who once hoped to identify one gene or a small set of genes responsible for disease resistance now realize that, in most cases, a plant responds to a disease through a complex interactive network of genes and signals.[20] Even within varieties of the same species, the response to a particular disease can be almost entirely different at the genetic level.[21]

For these reasons, Dr Leong sees genetically-engineered durable resistance as *"more of a concept than a proven fact."* While *"in theory one might imagine some kind of cassette of genes that can be incorporated into germplasm,"* she believes that the genes could not be incorporated without disrupting other important agronomic characteristics of the plant, such as time to maturity, grain size, growth, and taste.

If anyone should understand the difficulties of breeding for blast resistance it is Barbara Valent. She has spent the last 15 years working with a team of scientists at DuPont's laboratories in Delaware, USA, trying to find a means to genetically engineer rice for resistance to blast. Dr Valent speculates that durable resistance may one day come from *"protein evolution technology"* – the idea of creating artificial genes that can somehow create resistance more effectively than genes found in nature – but this technology is, at best, a long way off.[22]

Scientists are stumbling because they are looking for a reductionist answer to a complex problem. Both fungicides and breeding fail to control blast, because they are too static to deal with the dynamic relationships between plants and disease that are deeply tied to the surrounding ecology. Genetic engineering will not deliver durable resistance for this same reason.

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[18] Personal communication with Dr Sally Leong, 5 June 2000.

[19] Personal communication with Dr Chris Lamb, Toronto, Canada, 8 June 2000.

[20] Dr. Chris Lamb, "Biotechnology: Vanguard against plant disease," presentation at the Agriculture Biotechnology International Conference, 8 June 2000, Toronto, Canada.

[21] Dr. Stephen Briggs, "Functional Genomics and the Development of New Plants," presentation at the Agriculture Biotechnology International Conference, 8 June 2000, Toronto, Canada.

[22] Personal communication with Dr Barbara Valent, 9 June 2000.

Looking back to the future?

As geneticists struggle in biotech laboratories, others are enjoying successes in the field using traditional methods to control the disease. Dr Christopher Mundt of Oregon State University in the United States is working with IRRI and the Yunnan Agricultural University on a rice blast project in Yunnan, a southwestern province of China. The project utilizes a *"multi-line system"*, where different varieties of rice are planted in the same field to control blast.[23]

In Yunnan, blast is a severe problem and farmers often resort to eight applications of fungicides per season to try to control the disease. According to Mundt, the multi-line system has had an immediate impact: the severity of blast decreased by 95% and farmers did not have to apply any fungicides. IRRI claims that farmers participating in the project earned an additional US$150 per hectare from their harvests. By the end of 2000, up to 60,000 hectares in Yunnan will be planted to the multi-line scheme.[24]

Despite the project's success, there is resistance to the idea. According to Mundt, *"It's the people with the PhDs that have the biggest problem with it."* Farmers have been quite willing to try it out. This is logical, since farmers have used similar principles to manage blast for generations. Mundt says that the varieties that they chose to use for the project were actually suggested by a local farmer who was mixing the varieties successfully in his own field. In Vietnam, where Mundt is working on another multi-line project, the participating farmers told him that they remembered using similar strategies years ago, before the Green Revolution production model came in.

The multi-line system draws criticism because it goes against the basic tenets of industrial agriculture. It utilizes diversity, whereas industrial agriculture needs and breeds uniformity. By planting a variety of crops, the multi-line system prevents the intensification of the disease, keeping it at manageable levels for the rice plants to exert their own natural defences. It is only where uniformity is widespread that blast becomes dominant and is capable of causing severe damage. This was recently acknowledged by IRRI, one of the leading promoters of the Green Revolution: *"Simplification, or lack of diversity, has created a fragile biotic environment, which made crops vulnerable to pest and disease outbreak."*[25]

For agribusiness, it is this fragile environment of uniformity that drives and ensures its very profits. Industry sells a few varieties of (mainly hybrid) seeds over large areas, and this uniformity creates a need for agrochemicals and produces the raw material required for a homogenous global food system. Diversity interferes with this chain of events. For instance, under the multi-line system, the varieties may have different harvesting dates. This creates problems for mechanized farms, but not a problem for the overwhelming majority of farms in Asia, where the rice is manually harvested. Critics also charge that there would be differences in grain quality within a multi-line system that would complicate milling and sale. But when the rice from the different varieties was shown to farmers in Vietnam, they took one look and said that the differences were not a problem. It is only the large-scale food processors and traders that insist on completely uniform products. Which raises a crucial question. Who should agriculture feed: farmers and the local population or transnational agribusiness?

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[23] Personal communication with Dr Chris Mundt, 9 June 2000.

[24] *IRRI Annual Report, 1999*-2000, the Philippines, 2000, pp. 32-33.

[25] IRRI, "Research initiatives in cross ecosystem: Exploiting biodiversity for pest management," the Philippines, 2000.

For the Farmer-Scientist Partnership for Development (MASIPAG), a nationwide farmer-led breeding programme in the Philippines, rice blast can be managed by local farmers, without biotechnology. In MASIPAG's experience, blast is not a problem. However, if it occurs, the following are key principles they know that farmers can follow to manage it:[26]

1. wider spacing between plants;
2. judicious, timely and intermittent irrigation;
3. reduction of movements in the field to avoid transportation of spores, especially when the foliage is wet;
4. crop rotation to break the life cycle of the organism, thereby reducing the population;
5. planting different rice varieties, preferably with the same maturity;
6. saving the seeds from those plants that are resistant, for sowing the next season.

These strategies are all within the reach of resource-poor farmers in Asia. GE is not.

"Traitor Technology"

The days of tighter seed-chemical packaging are now approaching.[27] Syngenta, a recent merger between the agriculture divisions of Novartis and Zeneca, has already developed ways to combine the application of agrochemicals with the incorporation of disease resistance genes to enhance the overall resistance of plants. The obvious advantage of the combination for Syngenta is that any farmer growing its genetically engineered blast-resistant rice seed may also have to purchase and apply Syngenta's agrochemicals. Critics call this "Traitor Technology" because farmers enjoy the trait – blast resistance, in this case – only if they use the company's chemical triggers.

Syngenta has already received at least two "Traitor Tech" patents. US patents 5,614,395 and 6,031,153 are for chemically-induced or -enhanced disease resistance in plants engineered with a specific gene sequence linked to disease resistance. The latter patent covers the application of a number of widely used fungicides that can act as inducers, including mancozeb, metalaxyl, ridomil, fosetyl, and azoxystrobin. Syngenta is not the only company pursuing this strategy. Mitsui, in Japan, has a patent on a method for chemically inducing resistance to bacterial diseases, such as bacterial blight in rice.[28]

These patented technologies have been developed at a time when TNCs are moving into the rice market through the acquisition of hybrid rice companies.[29] Clearly, they intend to take over a portion of the breeding process from the public sector, which currently stands behind much of the rice seed market in Asia. One important difference between transgenic blast-resistant rice and conventional blast-resistant rice is that in the transgenic scenario, the genes will be patented

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[26] Personal communication with MASIPAG staff, 27 July 2000.

[27] Jim Bonman, "Rice Disease Management: Industry approaches and perspectives," ICPP98 Paper Number 3.6.7S, retrieved from http://www.bspp.org.uk/icpp98/abstracts/3.6/7S.html, on 11 October 1999.

[28] Patent: JP10262682.

[29] See *Hybrid Rice in Asia: An Unfolding Threat*, produced in the same series as this present volume, March 2000.

and owned by the private sector. In this manner, the industry can assert greater control over markets, influence national research and development, and extract more value from a country's rice economy.

Hot property: the travels of a blast gene

Whether they want to or not, international agricultural research centres (IARCs) have to recognize that their research intersects with the strategies of agribusiness. The work of IARCs in the "interest" of small farmers can be easily diverted by less lofty aspirations of scientists, venture capitalists, and TNCs, as seen below.

The early patents on genes for blast resistance are primarily on clones of genes already identified by breeders in the large number of traditional varieties with various levels of resistance to different strains of blast. Most of the varieties with blast resistance originate in Asia where the disease is believed to have originated, particularly India, Japan, and Yunnan province in China.[30] Other sources of resistant cultivars include the Philippines, Vietnam, Thailand and Colombia.[31]

On March 25, 1999, the World Intellectual Property Office published a patent by the Institute of Molecular Agrobiology (IMA) in Singapore for a blast-resistance gene from a rice variety (C101A51) derived from a rice variety called 5173.[32] According to the Consultative Group on International Agricultural Research, 5173 (or IRRI-IRGC-3970) is stored in IRRI's gene bank. The donor country is listed as the USA and the country of origin as the Philippines (though it was actually bred in India and arrived at IRRI via CIAT in Colombia).[33]

How did IMA come up with the patent? One of the inventors listed on the IMA patent is Dr Guo-Liang Wang – the principal investigator of IMA's rice disease resistance program at the time. Some years ago, Wang worked at IRRI, and after he left, he remained a regular borrower from IRRI's abundant gene bank. Wang is now at Ohio State University, where he works on a collaborative project with DuPont's genomics group to identify and study different genes in rice resistant to bacterial blight and blast.

In March 1998, Rhône-Poulenc (now Aventis) and IMA signed a *"Collaborative Research Agreement on genetically engineered or disease resistance in rice and functional genomics of rice."*[34] According to the press release, *"products resulting from this agreement will be commercialized by both parties, through a joint venture company to be established and based in Singapore."* Since the agreement with IMA, Aventis acquired Hybrid Rice International, one of the world's largest hybrid rice companies, and Granja 4 Irmaos, the largest rice seed company in Brazil.

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[30] K. Manibhushan Rao, *Rice Blast Disease*, Daya Publishing House, Delhi, India, 1994, pp.112 and personal communication with Dr Jim Correll, University of Arkansas, 6 June 2000.

[31] K. Manibhushan Rao, *Rice Blast Disease*, Daya Publishing House, Delhi, India, 1994, pp.112 and D.J. Mackill et al., "Genes for resistance to Philippine isolates of the rice blast pathogen," retrieved from http://probe.narusda.gov/otherdocs/rgn/rgn2/V2Vll28.html on 15 September 1999

[32] T. Inukai et al. "Blast resistance genes Pi-2(t) and Pi-z may be allelic," retrieved from http://probe.narusda.gov/otherdocs/rgn/rgn9/V9p90.html on 15 September 1999.

[33] Personal communication with Dr Fernando Correa, CIAT, 20 June 2000.

[34] Rhône-Poulenc Press Release, "Rhone-Poulenc Agro and the Institute of Molecular Agrobiology sign a research collaborative agreement in the field of rice biotechnology," Lyons and Singapore, 30 March 1998.

Genomics: the pipe dream continues

Small farmers are unlikely to be directly impacted by the introduction of blast-resistant transgenic rice, since it will probably not be affordable. Yet, they will certainly face the consequences of the indirect impacts that blast-resistant rice and other similar technologies will have. Research and development of genetically engineered blast resistance is part of a larger trend in disease management that will have deep impacts on all aspects of agricultural production.

At present, the genomes of a number of organisms, including rice and humans, are being mapped and their functions identified. International consortia and individual companies are mapping both the rice genome and the genome of the rice blast pathogen. With this genetic information, scientists plan to develop products, such as pesticides or pharmaceuticals, that can specifically target the genes of the disease that cause virulence in the affected host, or that can trigger an effective resistance response in the host itself. They also plan to genetically engineer the hosts for disease resistance, such as the first generation of blast-resistant rice – which is a very basic example of what scientists hope will eventually emerge. Scientists at Syngenta's Novartis Agricultural Discovery Institute, Inc. (NADII) are close to finishing their version of the rice genome map, which they call a *"RiceChip"*.[35]

The genomics approach to disease management offers profitable opportunities for the pesticides and seeds industry. For instance, breeding hybrid rice seed is laborious and fairly ineffective in terms of disease resistance, and it would be much easier for companies to stick to two or three varieties with the desired agronomic characteristics and then genetically engineer these varieties for disease resistance and other "high-value" traits. The inevitable outcome is much greater levels of genetic uniformity, which is only desirable for industry – both at the input and at the processing and trading end. It is not surprising, therefore, that the biotech industry has announced its intentions to move further into downstream sectors of rice production. DuPont recently formed a joint venture called RiceCo with operations around the world. RiceCo will not only sell agrochemicals and seeds, but will eventually set up contract schemes with farmers and then market the rice through partnerships with millers and maybe even with retailers. In the health sector, Syngenta is working with a US firm in California to grow transgenic rice that produces antibodies cloned from humans directed at the herpes simplex virus.[36]

Another outcome of these trends in agriculture disease management is increased concentration of knowledge with those who control the technology – the giant biotech transnational corporations (TNCs). As agriculture research and development continues to move further into biotechnology, researchers will become more and more dependent on high technology, which is controlled by a small number of biotech TNCs. For example, Syngenta's NADII has negotiated agreements with over 25 university and research institutions for access to its technology[37] – including a US$3 million deal with Clemson University for work on the genomes of rice and the rice blast

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[35] Dr. Stephen Briggs, "Functional Genomics and the Development of New Plants," presentation at the Agriculture Biotechnology International Conference, 8 June 2000, Toronto, Canada.

[36] Ibid.

[37] Ibid.

fungus.[38] If these trends continue, it will become practically impossible for public institutions to develop and apply their research independently from their private partners.

The farmers' verdict: friend or foe?

Genetic engineering, the cutting edge of science, will not conquer rice blast. On the contrary, it is more likely to compound problems with blast and other diseases by enhancing the conditions under which diseases thrive – uniform and intensive, chemical agriculture. For agrochemical corporations, the value of genetic engineering is not in how it helps to effectively fight diseases such as blast, but how it helps them organise agricultural research and production to increase their profits.

Winners and losers in the genetic engineering game: the case of rice blast in Asia

For companies, genetic engineering:

- provides an alternative to fungicides which are expensive to develop, have limited effectiveness due to resistance and have market limitations among poor farmers in Asia;
- gives companies more control over their products and the markets because of the nature of the technology and the patents they can secure;
- expands prospects for their agrochemical sales, especially under the "Traitor Technology" approach;
- allows them to introduce other high-value output or agronomic traits into their crops.

For resource-poor rice farmers in Asia, genetic engineering:

- offers no advantage in dealing with blast;
- locks them into a production system that is structurally designed to serve the needs of industry;
- increases dependency on the seed market;
- diverts research funding and focus away from more sustainable approaches to disease management and marginalizes farmers from R&D;
- is completely foreign to, and detached from, their own landscape.

This is not the time for more of the same. The formal agriculture research and development complex has failed to produce tangible improvements since the highly contested yield gains of its early Green Revolution years. Instead, conditions for most farmers in Asia have deteriorated, while the benefits have gone primarily to agribusiness, especially foreign agribusiness. This situation is deplorable and the need for a re-orientation of research and development to address the fundamental issues facing farmers in the region is abundantly clear. While biotechnology is often hailed as a solution to the current agricultural crisis, it is in fact a barrier to necessary change. It draws attention away from practical solutions by promising empty hype about high technology. It also strengthens the role of the private sector in determining the course of science, as the public sector rushes towards unequal partnerships with companies that own the necessary technologies or patents.

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[38] Novartis Press Release, 21 July 1998.

In the case of rice blast research in the private sector, genetic engineering is primarily a tool to increase dependence on the proprietary chemicals and other technologies of the pesticides industry. This is not a sensible way forward for Asia's rice economies. The only significant way to rectify the problems besetting agricultural R&D in the region is to take the decision-making process out of the board rooms and back into the fields.

Blast, biotech and big business

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).

The many people who gave time and information to the preparation of this paper are gratefully acknowledged.

Published jointly in August 2000.

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