Super Rice

Vision of a world without hunger

Super Rice holds the key to food security, Principal Plant Breeder and head of the Plant Breeding, Genetics and Biochemistry Division of the IRRI **Dr Gurdev Singh Khush** tells **Reaz Ahmad**

PLANT architecture of the world's number one crop will change dramatically by the turn of the century. One of the longest running rice research in the history nears completion with a promise to gift the world the much-aspired food security. The new plant type (NPT) of rice is now at its final stage and being developed by an expert team of plant breeders at the International Rice Research Institute (IRRI). Without exerting further stress on fast depleting natural resources like land and water, the NPT promises to enhance the global rice production by 25 per cent.

The man behind this decade-long revolutionary research on NPT is Dr Gurdev Singh Khush, Principal Plant Breeder, and the head of the Plant Breeding, Genetics and Biochemistry Division of the IRRI. Dr Khush has been spearheading a virtual crusade against an yield plateau in rice production since the evolution of the 'Miracle Rice' (first semi-dwarf modern variety IR-8) of Green Revolution era.

The World Food Award laureate was in Dhaka recently to deliver the theme lecture on *Cereal Improvement for Food Security in 21st Century* at the Bangladesh Rice Research Institute (BRRI). In an interview with *The Daily Star*, Dr Khush talked about food security and related issues, and, most interestingly, the latest development of 'Super Rice' as well as other frontier researches like transgenic rice (genetically engineered). Excerpt:

The Daily Star (DS): The issue of food security has emerged as a major concern these days. Do you foresee occurrences of hunger, starvation and malnutrition as the human race stands at the threshold of the third millennium?

Dr Gurdev Singh Khush (GSK): With 80 million people joining each year to put their stake on whatever food grain the world can produce, food insecurity is definitely a big concern. Today, some 800 million people go to bed hungry, almost half of them in India, Pakistan and Bangladesh.

Our objective should be to make sure that nobody goes to bed hungry. I think there would be major improvements in the 21st century. Standard of living has already gone up in South-east Asia. Their South Asian neighbours can't afford to lag behind.

With more education, we have to attack the population monster. Fortunately, there has already been a continuous decline in population growth rate. But, because of an already big population base, there would still be phenomenal increase in population.

There is a correlation between education and population rise. With more and more people in Asia getting educated and their standard of living elevating, we can hope certain degree of stability in population boom.

There should be more investment in agricultural research and also for the training purpose. Scientists require training in biotechnology. Educating next generation scientists would be the best investment that we can do today.

DS: Rice researchers have already made remarkable progress to compete the ever-increasing size of world population. As a plant breeder, how do you plan to face the challenge of feeding millions of new mouths?

GSK: During the Green Revolution era world rice production was doubled from 257 metric tonnes (MT) in 1966 to 520 MT in 1990. There is no such instances in the history of agriculture where production doubled in 25 years.

We have to continue the rate of production increase. The increased volume of grain has to come from developed varieties that have higher yield potentials and are tolerant to flooding, salinity and drought.

However, varieties alone cannot do the magic. We have to develop technology for water, pest and soil management. Location-specific technologies have to be developed. We have to facilitate the farmers in adopting better land management practices.

There should be inter-disciplinary approach — agronomists, breeders, entomologists and plant pathologists — all should work together. Besides, we have to develop expertise on biotechnology as well.

DS: Resource-poor Asians have already paid environmental cost to reap benefit out of the Green Revolution. Further exploitation of natural resources may pose serious threat to our livelihood, then what are the options left to explore?

GSK: If the Green Revolution had not succeeded there would have been famines. Some of the criticisms of the Green Revolution are justified, some are not. Distribution of Green Revolution benefit was equal. Not that, as some people tend to say, it had only benefited the rich farmers.

If you speak of water resources, I can tell you that technologies are available now to minimise water use substantially without hampering crop production. Nowadays a farmer needs not keep the fields flooded with water all the time.

We have to carefully monitor the recharge rate of aquifer. We can safely extract groundwater for irrigation purpose as long as similar amount of water is being replenished.

Time has come to think whether indiscriminate installation of shallow tube wells (STWs) is sustainable or not. There must be government controls over too much concentration of STWs.

Harnessing of surface water and building up storage capacity for preservation of excess water during rainy season could be a good solution to groundwater-stress problem.

DS: Promoters of wheat and maize consider that changes in food habit of the rice-eating Asians can itself resolve half the problem of food insecurity. Do you agree?

GSK: Partly, yes. Change in food habit can bring changes in demand-supply position of the principal cereals.

In Bangladesh, for example, you cannot grow wheat as much as you will be wanting to because of weather pattern. Of course, you have got a tremendous potential for growing maize in plenty. Maize is more suitable for use as poultry feed.

DS: Would you cast light on IRRI's efforts in developing cereal improvement. Is there any major breakthrough in sight ? How long will it take for 'Super Rice' to reach farmers' plots?

GSK: Most important projects in IRRI now aim to improve varieties, develop new plant type (NPT) and apply genetic engineering techniques. By next two years, hopefully, NPT will be made available to the NARS (national agricultural research system). Then the national governments may go for field tests and develop varieties suitable for local agro-ecological condition. The objective of developing NPT is to achieve 20 to 25 percent extra grain and break the current yield plateau.

DS: How do you look at the possibility of developing hybrid Super Rice?

GSK: Once we develop the NPT successfully, avenues for new possibilities would definitely open up. So possibility is always there to develop varieties through hybridisation between the NPT and MVs (modern varieties).

DS: Plant breeders like you have tremendous successes in developing high yielding varieties; however, it is often observed, virtual production in farmers' plots nowhere matches the yield potentials shown in demonstration fields. Do you think resource-poor farmers' incapability to provide better management is the only reason behind this yield gap?

GSK: It is partially true. The resource-poor cannot afford all the input as per the prescribed dozes. There is economic constraint; there is lack of knowledge as well.

Application of science in farmers plots not necessarily give the same output always. A lot of variables do work. Better yield largely depends on water availability, soil fertility and good management.

DS: The other day you were talking about the agro-ecological diversity in Bangladesh. What are the pragmatic steps that we can take to get benefit out of this diversity?

GSK: Yes, Bangladesh is a glaring example of rich agro-ecological diversity. Location-specific varieties and location-specific management can make a lot of difference. What you need first is good data about your soil types, water holding capacity, and saline condition. A soil survey map would be useful.

Land fragmentation is a major drawback for modern technology application. Land reform is required. Localised initiatives in the forms of farmers' co-operatives could be a good option.

DS: How do you see the potentials of more closer collaborations among the IRRI and the local institutions under the NARS functioning in Bangladesh ?

GSK: There exists a very good collaboration between the IRRI and the Bangladesh Rice Research Institute (BRRI). We have trained hundreds of Bangladeshi scientists. With the new project PETRRA (Poverty Alleviation Through Rice Research Assistance) launched further co-operation is expected. Besides, co-operation with non-government organisations (NGOs) is also there.

DS: IRRI has developed transgenic rice for quite sometime now -- why not releasing those ? Why the progresses are so slow in frontier research ?

GSK: Some people are concerned about bio-safety aspects of transgenic rice. Some fears are genuine, some unfounded.

You know there is a growing public concern about the end results of frontier researches. Some people are worried about allergic effects of transgenic rice.

The Philippines Bio-safety Committee just recently granted permission for field tests of transgenic rice. Hopefully by next month IRRI will get prepared for field tests at the UPLB (University of the Philippines, Los Banios) campus.

DS: In recent months more and more people interests groups have raised voice against GM food in the United Kingdom, as elsewhere in Europe. Prince Charles has raised alarm against fiddling with God's matters.

GSK: Yes, you are right. A lot of debates are going on these days but lest we should forget the basic fact that while developed countries with their population growth stabilised can afford a go-slow attitude towards GM food, the developing countries will be needing more food at any expense to feed a large number of people.

These developments, slow these are maybe, would definitely not hold us back from further advancing with frontier researches. One may choose to criticise scientific ventures as tinkling with God's matters but let me remind you all that it is science that has given us technologies to enhance world grain production. Otherwise, this world would have experienced more starvation and famines.

If the GM foods are properly tested and found non-injurious to health, there is no harm in consumption.

DS: Multinational giants are now taking more interest in agriculture than ever before. Their mergers with one other is a reflection of a business boom. As they go all-out to make profit out of lucrative seed and pesticide business, enjoying blessings of big governments in patenting life forms, don't you think that Third World farmers' rights are no longer well-protected?

GSK: The IPR (intellectual property rights) is a very complex issue. I am not actually update about the fast changing developments. Patenting of life forms is a much debated issue now.

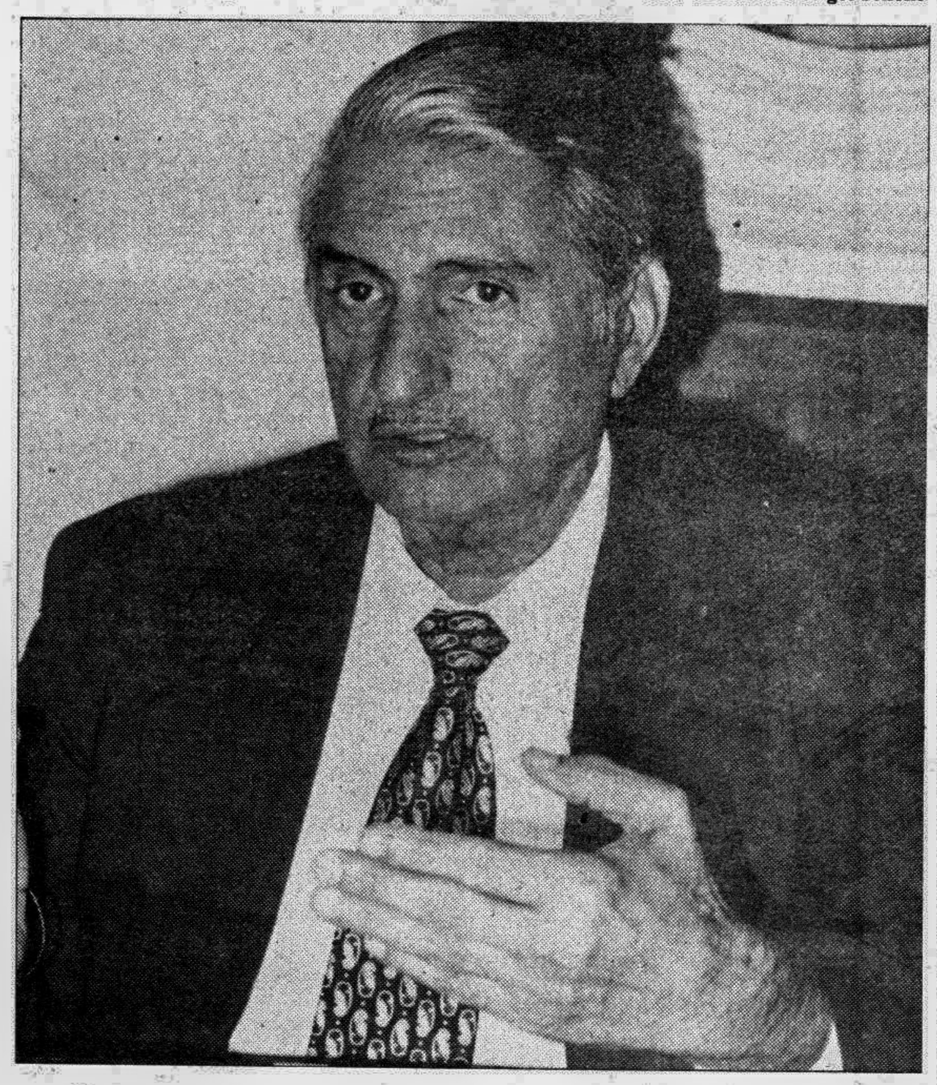
We have to keenly follow the developments under the new trade regime. I heard that just to meet world trade compulsions Japan would have to import rice despite the fact that it has enough already to feed its people.

The private companies are now investing a lot in research works and modifying micro-organisms for marketing purposes. Obviously, they need due return of their huge investment and they would be eyeing for optimum profit in future as well. Each nation would have to have policies to protect own rights and preserve national bio-diversity.

DS: All through your life recognition and awards came by your way with the latest one in December last -- the Rank Prize. After retirement from IRRI, what do you plan to do? Is their any dream kept close to your heart that you would like to pursue now?

GSK: I am 64. As per IRRI service rules, my retirement is due in August, 2000. But, I would like to complete the NPT work before leaving IRRI. I will train new breeders. Training the successors is important. So, I will be there on part-time basis.

The new plant type (NPT) of rice probably holds the key to the much-aspired food security.



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The new frontier

Being a densely-populated country having small land and very little scope of increasing rice area, it is all the more important for Bangladesh to increase the per unit yield in order to meet a growing demand for food supply, writes **Dr. A W Julfiquar**

THE yield level of modern rice varieties are plateauing. Evidently, exploitation of the potential triggered by the current phase of Green Revolution will be insufficient to sustain the required growth rate in rice production. Therefore, efforts must be made for a new frontier for more rice production. Development and use of hybrid rice has the potential to open up such production frontiers and contribute significantly to meeting the projected rice demand in the 21st century.

Hybrid rice is the commercial rice crop grown from F1 seeds of a cross between two genetically dissimilar parents. A good hybrid rice has the potential of yielding 15 to 20 per cent more than the best inbred variety grown under similar set of environment.

Hybrid technology has the following advantages:

1. higher yield (> 1 ton advantage over inbred);
2. higher farm returns;
3. higher stability of performance over environments;
4. faster replacement according to biophysical and socio-economic needs;
5. scope for further raising the yield ceiling through development and use of innovative MS systems;
6. increased employment opportunities in rural areas;
7. scope for diversification of rice based cropping systems based on land saving; and
8. scope for strengthening seed industry.

International Scenario

During the past 12 years, considerable progress has been made in development and use of this technology both in and outside China. Hybrid rice research is presently being conducted actively in 19 countries world-wide. The International Rice Research Institute (IRRI) has successfully explored problems and potentials of hybrid technology with encouraging results. Several countries established collaboration with IRRI to carry out research on hybrid rice. Currently hybrid rice research is in progress in 17 countries. IRRI bred parental lines have been used widely and has been commercialised recently in India, Vietnam and the Philippines.

China: Hybrid rice became highly successful in China where more than 50 per cent of the rice area is reported to be covered by hybrid rice yielding 20 per cent more than conventional rice varieties. During 1976-1991 hybrid rice helped China increase its production by nearly 200 million tonnes. According to an FAO estimate, higher productivity of hybrid rice enabled China reduce its area from 35.2 million hectare in 1978 to 32.5 million hectare in 1988, while increasing its production from 140 to 173 million tonnes during the same period.

India: The Indian Council of Agricultural Research (ICAR), New Delhi, identified this as a top priority area and initiated a time bound, goal oriented project on hybrid rice since December 1989. This project was further strengthened with the assistance from UNDP/FAO since September, 1991. Now this project is being operated through a national research network with twelve centres across the country. As a result of concerted, goal oriented, time bound and co-ordinated efforts, hybrid rice has become a field of reality in India. India is the first country outside China to release rice hybrids for commercial cultivation by the farmers. At present, ten publicbred hybrids have been released by the respective state variety release committees. About a dozen of hybrids from the private sector are also commercialised.

Vietnam: Farmers from Northern provinces have grown hybrid rice for testing and received an yield increase of 1.5 to 2.0 tons per hectare compared with local varieties. Encouraged by the yield potential of hybrid rice, Hybrid Rice Research and Extension have been officially initiated in Northern Vietnam in 1992. Three hybrid varieties have been developed. The total area of hybrid rice in the period 1992-1996 was 280,000 hectare yielding an additional amount of 350,000 tonnes which is 13 per cent of the total rice increase for this period. From a country deficit in food, nowadays, Vietnam can provide sufficient food for a population of 76 million people, ensuring food reserve and export on an average of 1.7-2.0 million tonnes of rice annually.

Philippines: PhiRice (the Philippine Rice Research Institute) and IRRI are spearheading the development of hybrid rice technology in the Philippines. Two hybrids have been developed and research is being conducted to develop more. Hybrid rice production programme was launched in April 1996. Under this programme, Philippines has a plan to increase hybrid rice area in the country from 500 hectare in 1998 to at least 50,000 hectare by 2002.

Hybrid seed production

One of the important part of hybrid rice is seed production for experimental hybrids and commercial hybrids to be grown by farmers. Synchronisation of days to flowering of seed and pollen parent is the key to attaining good out crossing on the seed parent. Strategies for synchronisation include staggered seeding and transplanting of male and female parents, sowing the male parent more than once to extend the duration for which pollen is available, and predicting and adjusting flowering dates.

Extensive research in China and at IRRI have led to identification of some guidelines for successful hybrid rice seed production for commercial cultivation by farmers. By using those practices hybrid seed yields of 1-2 t/ha can be obtained. In countries like Bangladesh where the hybrid seed industry has not been established, hybrid rice technology is considered difficult to adopt. For such situation IRRI has developed a self-sustaining system for hybrid seed production by which hybrid rice cultivators can produce their own hybrid seeds. The farmer can easily produce 25 kilograms of hybrid seed which is enough to cover a 1-ha farm area in the following season by adopting the self-sustaining seed production system. Using the procedures farmers need to buy only 400g of the A line and 1 Kg of the R line seed every season. The latter is not essential but is advisable to ensure seed purity. The public seed farms in such countries can produce the required quantities of foundation seeds of A and R lines for selling to the farmers who can adopt this technology with some training organised by the national programmes.

Economic Consideration

Major concern generally expressed about hybrid rice technology pertains to its economic viability. All studies in China showed that hybrid rice seed production is profitable, if hybrid seed yields range between 1.5 and 2t/ha. In their final analysis increased yield of about 1-1.5t/ha did overcompensate for the extra investment on seeds and chemical inputs. An economic analysis conducted at IRRI indicates that countries with a high labour-land ratio and a high proportion of irrigated area are likely to have the highest potential for hybrid rice technology. India, Vietnam and the Philippines already released some rice hybrids for commercial cultivation and Indonesia and Sri Lanka are actively involved in developing this technology. Seventeen countries around the world are also exploring prospects and benefits of this technology. Commercial success of hybrid rice in China and experimental results obtained at IRRI and several rice growing countries have clearly shown the potential of this technology to increase rice yields beyond the levels of semi-dwarf inbred varieties. Thus hybrid rice holds great promise to increase rice production and contribute significantly in meeting the projected global rice demand in the 21st century.

Status of Hybrid Rice in Bangladesh

Rice knowledge base and experience on various aspects of rice production, strong institutional infrastructure for seed production and technology transfer and receptive farming community to innovations in agriculture and positive policy environment make this country eminently suitable for launching hybrid technology programme.

From 1996 onward, hybrid rice research expanded in collaboration with IRRI and FAO, and more parental materials and hybrids were tested. Genetic tools to develop heterotic rice hybrids are available and can be deployed to develop heterotic hybrids. Several hybrids from IRRI were evaluated at BRRI Head quarter and different regional stations of BRRI under typical Boro condition. A good number of rice hybrids outyielded the standard check variety of the same duration by more than 1 t/ha. These hybrids are being tested further in on-station as well as on-farm trial and hopefully 1-2 hybrids may be released for commercial cultivation in near future.

Seed Industry in Bangladesh

The seed industry in Bangladesh has been growing fast since the announcement of the Seed Policy of Bangladesh in 1993. The Bangladesh Seed Merchants Association and the Bangladesh Seed Dealers Welfare Association have been functioning for a long time. In addition to above organisations, agro-chemical giants and well established NGOs are also active in seed production and marketing.

Conclusion

Among various technological options being contemplated, exploitation of hybrid vigour is the only one that is widely recognised and readily available means. Capable of giving an yield edge of at least a tonne per hectare over the best ruling variety in any given region, hybrids have contributed substantially to sustain the envisaged production growth as successfully demonstrated in China for over the last two decades. Increasing adoption of the technology in India and Vietnam since 1995 is expected to reveal its impact on production growth in the next five years.

Significantly, conviction on the potential of the technology at all levels and strong desire to give a try to the technology on the part of the government is bound to make hybrid rice a field reality. Hybrid rice technology undoubtedly is going to be one of the very potential tools, for achievement of food security during 21st century.

The author is a Principal Scientific Officer and the leader of Hybrid Rice project, BRRI