Feature — Science and Technology

Recent Advances in Biochemistry and Biotechnology

Rice: The Gene Revolution

By Dr. M Anwar Hossain

RICE (*Oryza sativa*) is one of the major cereal crops in the world. It is a staple food for almost half the world's population, most of whom live in Asia and Africa.

In Bangladesh, rice ranks first among the important cereal crops. It is not only the main source of carbohydrates but it also provides about 70 per cent of the dietary protein for the majority of the population of the country (Nutrition Survey of Bangladesh, 1981).

Bangladesh is not self-sufficient in rice. The average annual shortfall is between 1.5 to 2 million metric tons. Arable lands in Bangladesh are limited and its already large population is increasing with an annual growth rate of over 2 per cent. It is, therefore, imperative that rice production must increase to feed this ever growing population.

During the 1960's, 1970's and even 1980's, increases in irrigated rice fields and in productivity of rice through the development of HYV (High Yield Varieties) led to new strides in rice production that paralleled and sometimes even outpaced the population increase. That was the time of the green revolution. However, it is doubtful that this same kind of trend is possible today. This is because arable lands in our country have become a limiting factor and water is becoming scarce.

Increase in rice yield will, therefore, depend on innovations in varietal improvement. In addition to increased productivity, these innovations will include acquiring those traits in rice that will provide protection against various biotic and abiotic constraints. In our country some of these constraints are floods, droughts, salinity, pests and insects, diseases, weeds etc.

Rice has a long breeding history which made its phenotype (the observable traits and characteristics of an organism) wellknown, with some isolated traits such as growth cycle, diseases resistance, and its stalk height. Indeed rice improvement by breeding and selection has been very successful during the last 50-75 years. However, plant breeding is slow and painstaking process. Both desirable and undesirable genes (a gene is a length of DNA and also a short segment of a chromosome - a genes is responsible for a particular trait and is passed on from one generation to the next) are transferred in this process, thus necessitating the selection of lines with the most desired traits. To develop a new variety requires several generations and considerable time. By contrast, new rapidly emerging technologies like genetic engineering and biotechnology involving plant cell culture and DNA (Deoxyribo Nucleic Acid, a long double-stranded helical molecule in the nucleus which carries all the hereditary information of the living species) delivery systems offer the potential for the introduction of specific genes from any source into existing elite plant lines. Thus, these new technologies provide a powerful and novel means to supplement and as well as complement the traditional breeding, and together, these approaches will accelerate the development of new rice varieties with characteristics that cannot be obtained through breeding alone.

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Rice genetic engineering and biotechnology combine the knowledge of plant molecular biology, genetics and the transfer of foreign genes into rice cells. As has been mentioned, previous genetic research has discovered numerous phenotypic traits valuable in agriculture. But very few of the genes responsible for these traits have been characterized. The isolation of specific genes and the elucidation of their structures are, however, crucial for the success of genetic engineering of rice.

The size of the rice genome (the complete set of all different chromosomes found in each nucleus of a given species of organism) is one-sixth the genome size of wheat, making it the smallest among cultivated crops and vegetables. Owing to its small genome size, rice is a good model plant for studying plant molecular biology. This is one of the reasons why in the recent past a lot of attention has been focused on rice research in advanced countries. The Rockefeller Foundation initiated its International Rice Biotechnology Program in 1984. This event triggered an unprecedented zeal in rice research in the West. At the same time rice-producing developing countries, like China, India, Thailand and Philippines, gave high priority to rice research. Unfortunately Bangladesh is lagging far behind in this regard.

In the recently concluded (January, '95) International Conference on the Status of Plant Genome Research held in San Diego, California, it was shown that rice now has almost as many (DNA) complementary DNA representing a particular trait that is expressed) entries in the major data base as Arabidopsis, the model plant of plant molecular biology. This remarkable achievement is due primarily to the work of Japan's Rice Genome research Program (RGP). The goal of RGP is to isolate and characterize agronomically important and scientifically interesting rice genes that could lead to more robust and productive strains.

RGP is exchanging DNA markets with the International Rice Research Institute (IRRI) in the Philippines as well as with the rice genome mappers at Cornell University and the rice scientists at the John Innes Centre in Norwich, UK. This collaboration revealed that the major cereals like rice, wheat, barely, and rye share many similar genes that appear in the same relative positions of their chromosomes. The goal of their collaboration is to make a generalized map of the genome of the ancestral grass that gave rise to these cereals some 60 million years ago. On the other hand scientists at the IRRI are concentrating more on applied research to develop a super rice which will combine almost all the superior traits like fine quality, disease resistance, pest and insect resistance as well as high yield.

During the last five years (1989-94) remarkable progress has been achieved in efficient regeneration of cereal species from cultured cells, combined with novel methods for DNA delivery and selection. Rice was no exception in this regard. Upto 1993, successful regenerations from protoplasts have been reported for 10 different varieties of rice. These include both Japonica and Indica types.

It is difficult to track the ever increasing number of useful rice genes that have been cloned and characterized, but they include a bacterial blight resistance gene, a photoperiod sensitivity gene and a Green leafhopper resistance gene, genes for drought resistance in upland rice, flooding tolerance, and seedling vigor, etc have been reported.

Genes of agronomic importance, including those conferring high level of resistance to herbicides, viruses and insects have been successfully introduced into rice. The introduction of these useful genes is particularly noteworthy because nearly a third of all cereal productivity in the world is lost due to weeds, pests and pathogens.

It is almost certain that with the advent of genetic engineering and biotechnology, new varieties of rice with higher yield potential and adequate protection against biotic and abiotic constraints will be developed. This optimism was echoed in the report of the scientific committee of the seventh annual meeting of The Rockefeller Foundation International Program of Rice Biotechnology held in Bali, Indonesia, during May 16-20, 1994. Work on transformation of rice with value adding genes like yield-determining quantitative trait loci (QTLs), pest and insect resistance, viral, fungal and bacterial diseases resistance, male sterility and restoration of fertility to produce hybrid seeds, drought, salinity and flooding-tolerance, protein quality improvement, etc, are expected to be successful within this decade.

However it must be emphasised that the success and benefits of the above innovations arising out of new technologies will depend on

1) public acceptance of the engineered plants and their products;

2) demonstrated safety and superiority of the engineered plants; and, perhaps, most importantly,

3) their contribution to the development of a *sustainable* agricultural system;

The author is a Professor in the Department of Biochemistry at Dhaka University, whose work also includes research in the USA on isolating a flooding tolerance gene in rice.

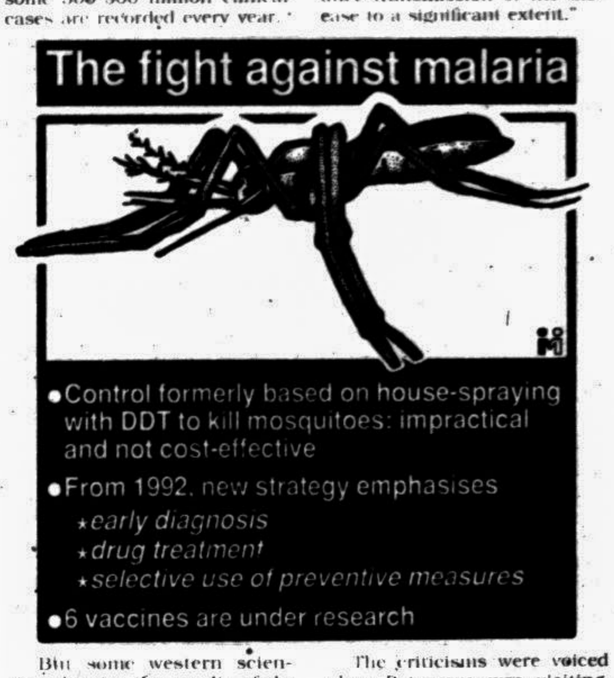
Fresh Controversy Over Patarroyo's Vaccine

by Zephania Ubwani

A malaria vaccine developed by a Colombian scientist has been tested in Tanzania and found safe for children, 1.5 million of whom die from the disease every year. But, some Western scientists doubt its effectiveness.

ATTEMPTS to evaluate a new malaria vaccine continue to be dogged by allegations that Western critics are biased against a Third World invention.

Field tests in Tanzania found that the vaccine, SPf66, reduced malaria among one-to-five year-olds by 31 per cent. The disease kills about one million children a year in sub-Saharan Africa. Worldwide some 300-500 million clinical cases are recorded every year.



But some western scientists dismiss the results of the two-year trial as of "marginal importance" and say more studies are needed before a decision can be taken on widespread use of the vaccine.

Colombia has expressed readiness to start large-scale production of SPf66 if it gets the go-ahead from the World Health Organization (WHO), which has been offered the patent by its inventor, Colombian scientists Dr Manuel E Patarroyo.

"Patarroyo donated the patent to the organisation after he had turned down an offer worth millions of dollars from a pharmaceuticals firm in the United States," says Prof Wenceslaus Kilama, director-general of Tanzania's National Institute for Medical Research.

WHO is planning a meeting this year which will collate all SPf66 results and decide a policy for future development.

Scepticism about the outcome of the tests at Idete village, 400 kilometres south-west of Dar es Salaam, is based partly on the limited number of malaria attacks during the trial.

Says Paul Henri-Lambert, chief of WHO's vaccine development unit: "A 31 per cent level of protection is a grey zone, at the edge of ineffectiveness."

A vaccine specialist with the United States Public Health Service, Roy Widdus, has cautioned that with a 31 per cent level "you will not reduce transmission of the disease to a significant extent."

The criticisms were voiced when Patarroyo was visiting Tanzania to see the field tests and to brief an international conference on the effectiveness of SPf66, which took him 12 years to develop.

African participants at the conference in Arusha criticised Western reactions, claiming that the negative remarks were made because Patarroyo was a scientist from the developing world. Many expressed concern that Western hesitations could jeopardise the fight against malaria.

Patarroyo, who is director of the Institute of Immunology in Bogota, brushed aside claims about the inefficacy of the vaccine. He said there had been a long propaganda war against his achievements from sections of the Western press.

"I know it would not be easy for people swallow the fact that I had made the first chemically-synthesized vaccine, the first vaccine against parasite disease and the first vaccine against malaria," he commented.

Doubts on efficacy were compound by the concentration in the tests on children aged one to five and the exclusion of infants, who are most at risk.

Marcel Tanner, head of the public health unit at the Swiss Tropical Institute, was quoted as saying they were not sure of effectiveness and safety for new-born babies or those under six months.

"That is important since most children who die from malaria in Africa do so between birth and one year," said Tanner, who had been coordinating trials at the Swiss-run Ifakara Centre near Idete.

However, he said that although SPf66's efficacy was lower than that of vaccines used against other infections, "since the burden of malaria morbidity and mortality is vast, measures with moderate efficacy merit development."

Prof Kilama is even more positive: "The study has shown that the vaccine could lower malaria deaths by about a third, something which would be an achievement not only in Tanzania but all of tropical Africa."

The Principal Secretary in the Ministry of Health, Rogasian Shirima, says that instead of being doubted, the vaccine should form a basis for more advanced research in order to improve its performance, "even in combination with other armaments against malaria."

Tanzania was chosen because it is one of the world's most malaria-prone countries: with an estimated 80 per cent of the country's 28 million people affected a year with official fatalities at 10,000.

Kilama says the first phase of the trial on 40 adults showed that the vaccine was safe. This was confirmed during the second phase, involving 50 children. In the third phase about 600 children were enrolled.

In the next few years, says Patarroyo, bigger trials involving between 15,000 and 150,000 people will be staged in Tanzania Mozambique, The Gambia, Thailand and Latin America.

Trials on Tanzanian and Mozambican children will be funded by Spain, where the vaccine was formulated and licensed for trials. — *Gemini News*

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Test Tube Baby Boom

by Neena Bhandari

Artificial insemination has suddenly become popular among Indian couples desperate to have a child of their own, but cannot do so by natural means.

INDIA, the world's biggest annual producer of human beings, is now also becoming one of the most fertile centres for test-tube babies.

A boom in artificial fertilisation is sweeping India and new clinics are springing up all over this nation of nearly 900 million people.

India's busiest test-tube baby centre is located in this city in western Rajasthan state. The Jaipur Fertility and Microsurgery Research Centre has already produced 30 babies, and 57 more women are expecting.

Most couples can ill afford the US$1,500 price tag of artificial insemination and the success rate is only 15 to 20 per cent. Still, at least 10 prospective parents come to the Jaipur Clinic every day for help in conceiving a baby.

"We don't mind a boy or a girl, but we will not adopt. When your child is not really your own, what can you say of another's child," says one woman who has travelled here from the Bastar region of Central India, 1,500 km away.

"All the money you earn and hard work you put in is futile if you don't have children. I am so lonely that this time if we do not succeed we will adopt a child," says the wife of a factory worker from Vijaywada district in southern India.

"It is only people who do not have children who can realise what it is like not to have one," she adds.

The rate of adoption in India is increasing, but the pace is still slow and the desire to have one's own babies remains strong.

In rural India, a woman who does not conceive within a few years after marriage is looked down upon as inauspicious and not allowed to participate in religious ceremonies, although it is usually the husband's low sperm count that is the cause.

The Jaipur clinic's Dr Swarankar says: "Most couples come to me as though I have a divine power and can give them what providence has denied, but there are limitations."

In the IVF embryo transfer technique, the fertilised egg is kept in a petri dish for 24 to 72 hours before being transferred to a woman's uterus. This is used where both fallopian tubes are either absent or blocked in women.

The pregnancy rate through the IVF-embryo transfer method is 20 per cent and involves at least three attempts. The egg is retrieved from the ovaries through a fine needle and placed in an incubator to be inseminated with approximately 100,000 washed mobile sperms.

The other technique is the gamete intra-fallopian transfer performed on women who have at least one normal fallopian tube. The pregnancy rate through this method ranges between 20 and 30 per cent.

Swarankar induces ovulation to get as many as six eggs which he mixes with at least 200,000 active sperms. He then transfers the sperms to the end of the healthy fallopian tube with a fine tube through a small incision in the abdomen.

Patients are open to risks of infection, haemorrhage, injury to the bladder, bowel or other intra-abdominal parts that may necessitate emergency surgery.

When the donor of the sperm is unknown, the risk of passing on genetic disorders and even acquiring deadly diseases like aids increases. Deep freezing of sperm in liquid nitrogen and testing them after the incubation period of the aids virus is over has considerably lessened this risk, say doctors.

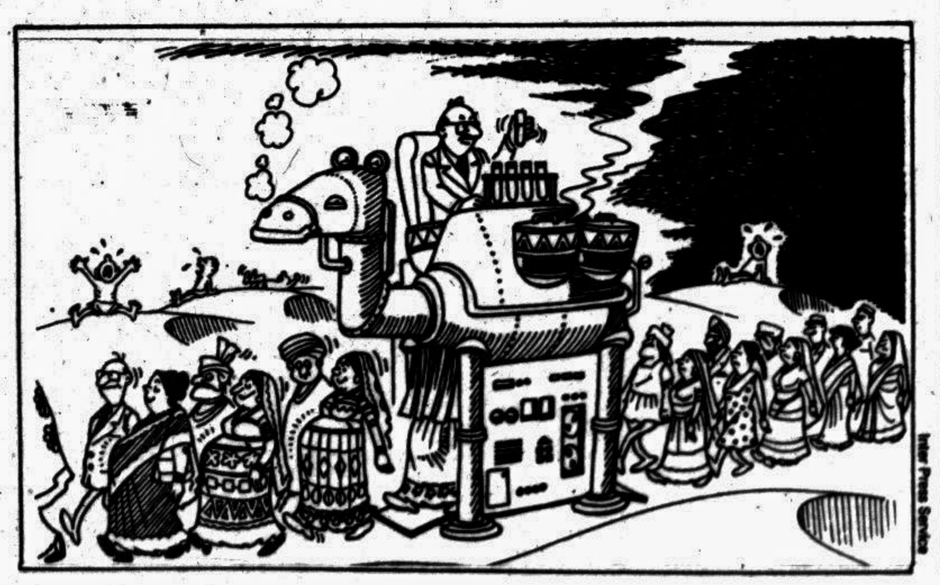
But patients are not complaining. For them, the joy of having a child of their own is compensation enough.

Critics say adoption should be encouraged in a country where thousands of children are homeless and hungry. They say a test-tube baby boom in a country that produces more babies every year then China is an anomaly.

But most specialists believe the issues of adoption, population and artificial fertilisation should not be linked.

"Test-tube babies are an advancement in technology and not related to population per se. People who don't have babies and are helped through an invention to reproduce, should have babies," says Anu Gupta, project executive at the Parivar Seva Sanstha in New Delhi that markets contraceptives.

Gynaecologist C K M Sharma agrees: "Every woman dreams of becoming a mother and has the right to have a child. One should promote family planning, but not deny the right to someone to have a child... it has noting to do with population control.



Inter Press Service

Total Recycling of Disused Televisions

A Berlin-based company, Video Computer Recycling GmbH, VICOR, has now developed the first truly "green" technology to dispose of disused television sets. Although this is not the first such system, the engineers Reinhard Schmidtmann and Hans-Georg Glatzel have developed a greatly improved recycling process. In conventional systems, the picture tubes are first broken up and then mixed with a special liquid to dissolve out the fluorescent materials — a method which has given rise to serious ecological problems. In addition, the shattered glass was unsuitable for further recycling because it could not be presorted. The glass of the neck, cone and screen all have a different chemical composition, containing either high concentrations of lead oxide or barium oxide.

The Berlin engineers have now developed an environmentally-friendly process to solve these problems. At the heart of their recycling system is a new thermal-mechanical drying process which enables the various types of glass used in the picture tubes to be separated and rendered suitable for recycling. The plant has been designed to recognise immediately the size of the picture tube to be processed and adjust accordingly. Subsequently, all the components of the picture tube, including the screen, the cone and the forms, are dismantled and stored in special containers, before being used in the manufacture of new components.

The phosphors are then removed from the screen using a mechanical drying process and stored in a sealed container in the filter system. Weighing only 0.04 percent of the original picture tube — negligible compared to conventional methods — this residue must finally be disposed of in a special dump.

Bettina Reckter

The Scientific Faith?

by Humaira Binte Asad

ABOUT 1500 years ago, when ignorance and superstition ruled the earth and darkness curtained the wind from truth, a light suddenly shone in 'Hera', to dazzle the whole world with a heavenly command;

"IKKRA BISMI RABBI KALLAZI KHALAK"

"Read in the name of the Lord who createth"

— Surah XCVI, Verse 1.

In that era of dark ignorance, the Quran demanded only one thing, not *salaat* or *sivam*, but to acquire knowledge. The Quran — this Holy guidance deals with problems from daily household routine to state politics, from economics, law and foreign affairs to arts and science.

A long history of research lies behind our present understanding and perception of the profound similarities between aspects of science today and the Quran 1500 years ago. According to Professor Keith L Moore, "The long delay in interpreting these verses correctly resulted mainly from inaccurate translation and commentaries, and from a lack of awareness of scientific knowledge".

Take embryology; the heavenly Verse declared:

"Was he not a drop of fluid, which gushed forth?" — Surah LXXV, Verse 37.

Twentieth century science has proved that the first phase of architecture of the human being is designed with the formation of sperm and ovum. About 2-4ml of semen is ejaculated per coitus, containing 100-200 millions of spermatozoa per millilitre. Only a drop of this semen is required for fertilization. And, in fact, the Quran states:

"Lo! We create men from a drop of *thickened fluid* to test him". — Surah LXXVI, Verse 2

According to Dr Maurice Bucaillae the *antsaj* does not only mean "thickened fluid" (as mentioned) but also a mixture. And, yes, it is a mixture.

"The semen which is ejaculated during the male sexual act is composed of fluids from the vas deferens, from seminal vesicles, from the prostate glands, and from the mucous glands, especially the bulbourethral gland." (The text book of Medical Physiology, Guyton — 7th Edition.)

"He makes you in the wombs of your mother in stages, one after another in three veils of darkness." — Al Quran.

Let us turn to Prof. Moore's explanations of this verse. "The 'three veils of darkness', may refer to (1) the anterior abdominal wall, (2) the uterine wall, and (3) the amnio — chorionic member.

The Quran declared:

"Then We placed him as a drop in a place of rest." — Surah XXIII: 13

Prof. Keith L Moore explains, "The drop of *'nutfa'* has been interpreted as the spermatozoa, but a more meaningful interpretation would be the zygote which divides to form a blastocyst which implants in the uterus, (a place of rest)."

"Then We made the drop into a leech like structure." — Surah XXIII: 14.

Again to Prof. Moore: "The word *'alaca'* refers to a leech or bloodsucker. This is an appropriate description of the human embryo from days 7-24, when it clings to the endometrium of the uterus in the same way that a leech clings to the skin".

"Then of that leech-like structure, We made a chewed lump." —XXIII: 14.

"The Arabic word *mudghah* means chewed substance or chewed lump. Toward the end of the fourth week, the human embryo looks like a chewed lump of flesh," according to Moore.

"Then We made out of the chewed lump bones, and clothed the bones in flesh." — XXIII: 14

Prof. Moore: "This is in accordance with embryological development. First the bones form as cartilage models and then the muscles (flesh) develop around them from the somatic mesoderom."

"Then We developed out of it another creature." —XXIII:14

"This may refer to the human like embryo that forms by the end of the eight week. At this stage it has distinctive human characteristics and possesses the primordia of all the internal and external organs and parts. After the 8th week the human embryo is called a fetus. This may be the new creature to which the verse refers," Prof. Moore suggests.

The human being is thus brought forth to this earth. The variety of human life, makes the world a mystery. With happiness, with sorrow, with surprise, or with boredom, we can but accept life as a fact. But what wonder is contained in our search for knowledge in life.

In conclusion, to quote Prof. Moore again,

"The interpretation of the verses in the Quran referring to human development would not have been possible in the 7th century AD, or even a hundred years ago. We can interpret them now because the science of modern embryology affords us new understanding. Undoubtedly there are other verses in the Quran related to human development that will be understood in the future as our knowledge increases."