in the development of instrumentation for physics research, by organizing a special seminar exclusively on this aspect. In the session on 'News and views' one had the glimpses of hardware development, but all the discussions were centred on the development of the national faciities.

In summary, the 43rd SSPS was a very satisfying one, both from its scientific content and the social features. All the aspects of the symposium were taken care of in a praiseworthy manner, as a result of commendable efforts of the organizers of the symposium and local hosts.

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International rice genetics symposium*

In a matter of two decades, rice genetics has taken new strides and rice is no longer a poor cousin of maize and wheat in terms of genetic information. With the advent of International Programme on Rice Biotechnology (IPRB) sponsored by the Rockefeller Foundation, it moved to centre stage of molecular genetic research. This paradigm shift is visible in the successive International Rice Genetics Symposia (IRGS) held once in five years. It all began with the first IRGS held at International Rice Research Institute (IRRI), Philippines in 1985 at which time Rice Genetic Cooperative was also established, paving way for international collaboration in rice genetics. The same year also saw the establishment of IPRB. By the time the second IRGS was held in 1990, the impact of international collaboration in rice genetics and biotechnology was apparent. Molecular biologists made inroads into rice research. Developments in genetic transformation and DNA marker technology have advanced the cause of rice genetics, providing better insight into the rice genome. Five years later, the advances are spectacular with the ascent of rice to the top among cereals and a model among the monocots.

The 4th IRGS held recently was structured in the form of plenary sessions (7), concurrent sessions (6) and poster sessions (11), to provide room for all forms of interaction among the four hundred and odd rice scientists representing 28 countries.

Lead papers were presented in the areas of Rice genetics – Present and future, Bio-systematics and evolution, Molecular markers and QTL mapping, Comparative and structural genomics, Genetic resources for functional genomics, Gene isolation and function and transformation.

In the first plenary presentation by Gurdev Khush (IRRI), significant developments in rice genetics from Mendel to functional genomics were highlighted. J. N. Rutger (USDA) gave an account of application of Mendelian genetics that led to many breeding advances in rice. Of considerable interest was the presentation of Qifa Zhang (China) on the genetic and molecular basis of heterosis in rice, wherein he demonstrated the involvement of a large number of epistatic interactions as the genetic basis of heterosis and the relationship between gene expression and heterosis with differential display analysis.

'Quantitative evaluation of species relationship in the genus *Oryza* using molecular markers' by H. Morishima (Japan) showed that the pattern was largely agreeable to that so far conceived. Using three genes – two nuclear genes (*Adh1* and *Adh2*) and one chloroplast gene *matK* – S. Ge (Beijing, China) presented evidence to support the previous recognition of nine genome types. Nevertheless a new genome type HK was recognized for *O. schlechteri* and *Porteresia coarctata*, suggesting *P. coarctata* belongs to genus *Oryza*. Sue Wessler (Georgia, USA) presented a paper on functional genome approach to the study of miniature inverted repeat transposable elements (MITES) and their role in genome diversity. Susan McCouch (Cornell, USA) gave an update on microsatellites in rice – abundance, diversity and applications. To date, a set of 500 microsatlellite markers have been mapped onto rice genome, providing rice breeders and geneticists with an efficient and highly informative set of DNA markers that can be used for variety protection, diversity analysis, marker-assisted selection, gene isolation and QTL identification. Dave Mackill (University of California, Davis, USA) reviewed the important applications of molecular mapping for (i) determining the allelism of genes conferring identical phenotypes, (ii) selection or pyramiding of non-allelic genes in a breeding programme and positional cloning of genes, citing examples to illustrate how such tools can be integrated into breeding programmes. Zhi-Kang Li (IRRI, Philippines) made a critical analysis of QTL mapping in rice to show that epistasis and QTL × environment interaction remain the twin challenges in QTL mapping and proposed two strategies – genetic and physiological dissection and use of introgression lines to improve the power of QTL detection and integrate QTL identification in rice improvement.

When the first dense maps of cereal genomes were constructed by the application of DNA markers a decade ago, it was clear that gene content and gene order along the chromosome were remarkably similar to related species than it was thought to be. Early comparative studies of wheat, maize and rice established synteny between the major cereals. Further, studies on comparative genetics extended to related grasses and their wild relatives suggest that rice, with one of the smallest genomes (430 Mb) is providing link between species as diverse as foxtail millet, *Setaria italica* and rye grass, *Lolium perenne*. Mike Gale (John Innes Centre, UK) traced these developments in comparative genetics to show how similarities in the gene and chromosome organization and conversely the conserved differences in the form of chromosomal rearrangements are of evolutionary significance. Duplication of quite large regions of the genome, for example, as in chromosomes 11 and 12 of rice, is common and seems to be an evolutionary feature that has emerged through such studies.

Rod Wing (Clemson University, USA) presented the programme and status of CCW rice genome sequencing consortium of Clemson University Genomics Institute (CUG), Cold Spring Harbor, Washington University Genome Sequen-

*A report on the Fourth International Rice Genetics Symposium organized jointly by the International Rice Genetics Cooperative and International Rice Research Institute (IRRI) during 22–27 October 2000 at IRRI, Los Banos, Philippines.

cing Centre whose focus is to sequence and annotate the short arms of rice chromosomes 10 and 3. As a prelude to rice genome sequencing, the centre has focused on development of sequence-tagged connector (STC/BAC) fingerprint framework. Sequencing resulted in generation of 63432 and 47006 end sequences from *Hin*dIII and *Eco*R1 libraries, respectively and comprises 36 Mb of high quality rice genomic sequence deposits in the Gene Bank.

Takuji Sasaki (National Institute of Agrobiological Resources, Tsukuba, Japan) gave an update on the status of International Rice Genome Sequencing Project (IRGSP). At present 15 laboratories from 10 countries have joined IRGSP and share the sequence work of 10 out of 12 rice chromosome complement. India has joined hands with other countries to undertake sequencing a part of rice chromosome 11 – a 10 Mb segment, over the next five years. The most advanced stages of chromosome sequencing are related to those of chromosomes 1 and 6 by Japan and 10 by USA. Several types of sequence data contributed by Monsanto to IRGSP should hasten the completion of sequencing of japonica variety, Nipponbare sooner than expected.

B. A. Antonio (Tsukuba) discussed the subject of bioinformatics and the rice genome. A rice genome database named INE (integrated rice genome explorer) has been developed to access enormous genomic information. INE provides graphic interface of the linkage map, the physical map with ordered YAC clones, an EST map and the PAC contigs with the corresponding sequence. The genome sequence is directly linked with mapped DNA markers for accurate localization in the chromosome.

Masahiro Yano (Japan) showed how naturally occurring allelic variation could be a new resource for functional analysis of rice genes. Hei Leung (IRRI) presented progress in phenotyping sequence assignment for deletion mutants in functional genomics. G. An (Korea) gave an account of generation of T-DNA insertional tagging lines in rice. Of considerable interest was the presentation by Guo-Liang (Ohio State University, Columbus, USA) on structure, function and evolution of disease-resistance genes. The first resistance gene cloned in rice is *Xa21* introgressed from wild rice *Oryza longistaminata*. Sequence analysis of seven members at the locus suggests that duplication, recombination and transposition have occurred during the evolution of the gene family. Ande Pereira (Plant Research International, Wageningen) gave an account of how maize transposon-derived constructs can be used to create and analyse mutations in the rice genome by generating knockout and gene detection insertions in the rice cultivar, Nipponbare.

IRRI's approach to achieving synthetic apomixis was presented by John Bennett. It envisions the generation of an apomictic embryo in the nucellus of the ovule of hybrid rice plants. The endosperm would develop normally as a result of selfing of the hybrid, but the sexual embryo that is also produced due to selfing needs to be eliminated. Transgenic approach to generate rice plants tolerant to dehydration stress was presented by Ray Wu (Cornell). Paul Christou (Norwich) discussed factors affecting transgene integration, organization and expression in cereals. Unpredictable rearrangements in transgenes occurring in plasmids in co-transformation can be avoided by use of clean DNA system (promoter, coding sequence and terminator) that facilitates direct transformation with multiple genes and rare silencing.

Besides plenary presentations, several papers were presented in concurrent and poster sessions. A unique feature of the IRGS was the three satellite workshops on contemporary topics, viz. molecular breeding, functional genomics and bioinformatics.

At the Workshop on International Molecular Breeding Programme, an overview was presented by Zhi-Kang Li and progress to date was reviewed by Lijun Luo (China), Weijun and J. Ali (IRRI). Discussion was followed on selection strategies for target traits (backcross and phenotype strategy), information and database establishment and sources of support, as well as human resource development.

A functional genomics workshop was held with Mike Gale (UK) and Hei Leung (IRRI) as facilitators. Rice will be the first food crop to be completely sequenced. The sequencing of rice was spearheaded by Rice Genome Research Programme (RGP) of Japan and now expanded to an IRGSP. This effort was largely supported by governmental funds and boosted by doubling of rice genomics budget in Japan and the US and an investment to the tune of Rs 49 crore by the Government of India.

IRRI proposed the formation of an international working group on functional genomics with high priority of the following: (i) Creation of information mode to deposit and disseminate information on rice functional genomics; (ii) Building a public platform to promote access to genetic stocks and phenotypic information; (iii) Developing database on phenotypes and mutants with linkage to sequencing laboratories; and (iv) Initiating partnerships to develop resources for micro array analysis.

The Rice Bioinformatic Workshop was headed by a seven-member expert panel – Mike Jackson (IRRI), Bal Antonio (NIAR, Tsukuba), Angela Baldo, (USDA-ARS, Cornell), Richard Bruskiewich (IRRI), Robin Buell (TIGR, Maryland, USA), Nori Kurata (Japanese Ministry of Education Culture and Science, Japan) and Graham Mc Laren (IRRI). The issues for discussion were current objectives for bioinformatics development within the rice research community, collaborative framework that needs to be established to achieve those objectives, specific technical areas for focus and assignment of responsibility to coordinate the developments in those areas.

Successive reviews of the IRGS show the impact of molecular biology on rice genetics. By 1995 when the 3rd IRGS was held, there was an invasion of molecular biologists at the expense of traditional rice breeders and geneticists who are the real players in rice improvement. Indeed the late Ralph Riley did point this obvious shift in the earlier meeting. At the 4th IRGS, it was the turn of functional genomics, DNA markers and QTL mapping. Behind all these developments is the support of Rockefeller Foundation's IPRB that just ended last year as well as the RGP of Japan. IPRB has sown the seeds of alliance between advanced laboratories in developed countries, largely with molecular biology expertise and national agricultural research scientists from the developing world. Rice genome research programme initiated at Tsukuba is the forerunner of International Network on Rice Genome Sequencing established in 1998, ushering an era of international collaboration in rice genome sequencing.

Being a crop of poor Asian farmers, rice was not as attractive as maize for the corporate sector to invest in research in the past. With the spurt in rice research through the application of molecular tools and the demonstrated commercial feasibility of hybrid technology, rice has attracted corporate investments. Expectedly, such investments aim at reaping the benefits through products for profit and denial to poor farmers. IRRI and rice community hope for 'a shared vision in rice research that provides public sector access and freedom to use modern tools and sufficient incentives to those who invest and invent, develop and deliver new rice technologies'. A recent announcement by Monsanto of its working draft of the rice genome and its willingness to share the data with an international consortium, the IRGSP, is a laudable example of forging public and private sector collaboration in rice genomics. Another one is the Golden Rice – a *tour de force* in genetic engineering and the inventor's offer of technology transfer free of cost to select national agricultural research systems for the benefit of millions of rice eaters that suffer from vitamin A deficiency.

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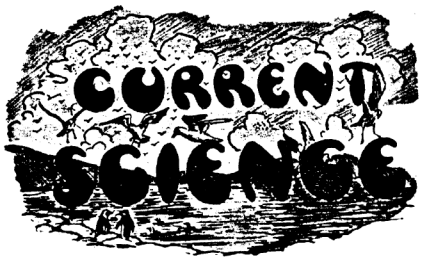
FROM THE ARCHIVES



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The problem of malnutrition in India

The fact that millions – perhaps the majority – of the people of India suffer from various degrees of malnutrition seems beyond dispute. It is true that more precise data on this question are required – data which can be collected only by dietary surveys, and the systematic physical examination of sections of the population to reveal the incidence of states of malnutrition and deficiency disease. But sufficient information already exists to prove that malnutrition is widespread. If the diets of the majority of the population, particularly of the poorer classes, are compared, even in a rough qualitative way, with the dietary standards put forward by modern physiologists, it at once becomes apparent that the former fall short of adequacy; in general, they are deficient in the more valuable proteins, and in certain vitamins and mineral salts. Again, food deficiency diseases – beriberi certain forms of anaemia, epidemic dropsy, xerophthalmia, etc. – are common throughout most of India. The poor physique and lack of resistance to infection shown by the majority of the population in many parts of the country also suggest that the average Indian diet is a defective one.

It should be realised that this state of affairs is not peculiar to India; that, in fact, the same problem exists in most countries of the world. Outside Western and Central Europe, North America, Australia and New Zealand, and perhaps a few other fortunate countries, the diet of the mass of the population is not very different in quality from that of the poorer classes in India. Thirty or forty years ago, malnutrition and certain food deficiency diseases – e.g. rickets – were very common in England; it is only gradually that the dietary level of the masses is being raised even in the most prosperous countries. To-day China presents a problem of malnutrition which is as formidable as that of India, and there is evidence that other Eastern countries, such as Java, Malaya, and Japan, are in a scarcely more favourable position. The question of malnutrition in South America has been little studied as yet, but quite recently the authorities of one South American country very remote from India – Chile – have reached the conclusion that dietary deficiency is one of the main causes of ill-health and disease in that country, and are taking steps to investigate and remedy the situation. It may well be that, for a number of reasons connected with religion and climate, the problem of dietary deficiency in India is more difficult of attack than elsewhere, but the difference is one of degree, not of kind. While economists talk of overproduction of foodstuffs, the greater part of the world's population would be the better for more food of superior quality to eat.

The problem of malnutrition in the village might be approached by selecting small 'demonstration' rural areas for intensive work. Data about dietary habits could be collected by careful surveys involving a number of families, and subsequently correlated with the 'state of nutrition' of the population group concerned. The exact nature of the deficiencies in the diet would thus be made apparent. The next step would be to attempt to improve nutrition in the 'demonstration' area by various means – education and propaganda, maternity and child welfare work, improvement in livestock and agricultural production, etc. The chief aim of a public health nutrition experiment of the type outlined would be to investigate the possibilities of improvement lying within the resources of the people themselves. Results obtained in small areas might have a general application throughout the country.

If the public health side of nutrition work is to develop in the right direction, it is essential that adequately equipped research institutions should exist to provide basic knowledge. Nutrition research is being actively carried on at Coonoor and elsewhere, but there is room for extension of existing institutions working in this field and for the creation of new ones. Sir Robert McCarrison, writing in *Current Science* in July 1932, suggested that 'each Presidency or Province should have its own Institute for the study of Nutrition'. The activities of the ideal nutrition research institute should include basic scientific research, systematic surveys of foodstuffs, study of cheap well-balanced diets within the means of the poorer classes, field and epidemiological investigations, and a good deal of propaganda and education work. It should have a department for training public health workers of various kinds.

Researches in animal husbandry, nutrition, agriculture, and human nutrition, and efforts to apply in practice the results of scientific research in these fields, are complementary and directed towards the same end. The greatest possible co-operation between those concerned in these activities is desirable.

W. R. AYKROYD