Typus lectus e stercore equino, in collibus Mussoorie in U.P. in India, 12 October 1962, a B.C.L. (Herb. RUBL No. 194).

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THE BREEDING OF HIGH PROTEIN RICES

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RICE as a food crop has some important advantageous features, namely, wide adaptability to different soils, high productivity per unit area and also the ability to yield well in plots with standing water. It is generally realised that the protein content of the milled raw rice, being between 5 and 7%, is low especially when compared to wheat. Nutritionists advocate enriching the rice, alternatively supplementing with high protein food. It is a challenge to rice breeders to evolve high protein varieties.

A large number of grain (rice) protein estimations have been made in this Institute using a number of rice genotypes grown in the two rice seasons and under varying manurial treatments. It was consistently found that the rice protein percentage is the end result of genotype/environment interaction. Precise control of supply of the major nutrients is achieved in water cultures and one water culture experiment showed that N absorption upto maturity increased protein content of grain. In another experiment using the popular short duration variety Ptb. 10, and water culture, it was found that with N concentration of 200 parts per million the rice protein could be raised to 18%, when the nutrient solution is retained to maturity. Protein estimation in these and other experiments were from brown rice with intact pericarp and embryo, the factor 6·25 being used to convert N values to protein. A further series of pot experiments showed that the genotype controlled the upper limits of protein, as for instance the cultivated rice of West Africa, *O. glaberrima* surpassed some popular *indica* varieties in protein content at high rates of N application.

In an early study in this Institute, Sampath and Seshu[1] had compared protein content of a few genotypes and had suggested that the morphological character "long glume" may be correlated with high protein content. Subsequent work failed to confirm this suggestion, but in the screening, the variety *Pirurutong* of Philippines' having long glumes was found to have protein content of 10·4% and this is significant when under similar conditions the U.S.A. variety *Rexoro* had a protein content of 7·40%. For, in the *Annual Report of the International Rice Research Institute*[2] (1961-62) a table gives the proximate percentage composition of 16 rice varieties from different countries, and in this group *Rexoro* had the highest protein content.

A project for breeding high protein rices was started in this Institute in 1965, using *Pirurutong* as one parent and the *japonica* variety *Gaisen mochi* as the other parent. The *japonica* was used as the other parent to contribute to productivity of the progeny selection through genes for short height, and manurial response. Chemical analysis of a few F_3 selection showed that the protein percentage varied with the plant, and a few having more than 10% protein were multiplied. In 1967 *Kharif* season (July to October) the cultures were fertilised with ammonium sulphate in two applications, the total being equivalent to 90 lb. N/acre. Analysis of samples showed that there was considerable variation between plants but in four plants the protein content of rice exceeded 15%. These are being multiplied in highly manured plots.

The cultures are potentially high-yielding but are susceptible to bacterial leaf-blight. They have been subjected to chemical mutagenesis and the M_2 generation is being grown, to be screened for blight resistance. However, there are other promising rice varieties which could be used in a new breeding project and it is necessary to consider the criteria to be used in selecting the parents. It is necessary to know about the range of variability amongst common varieties and the compilation by Juliano[3] on the physico-chemical data on the rice grain is very useful. Since high protein content should be accompanied by high-yielding capacity, it is necessary to select parents having other desirable features, for example, resistance to *Piricularia*, inasmuch as heavy manuring is to be adopted. In this connection, the report by Swaminathan[4] that mutation breeding has given a high-yielding high protein wheat strain, and parallel results are to be expected in rice, is important. Such mutants, even if not high-yielding, are of value in breeding. For efficient breeding, it is, however, desirable to investigate the genetic control of protein level in the grain.

The hybridisation programme now reported needs to be continued for the following reason. Both the parents used have the "Waxy" endosperm, that is the starch is predominantly amylopectin. This character is recessive to the normal starchy (amylose + amylopectin) and the genetic locus is designated *wx*. From this hybrid, segregation to "starchy grain" cannot be expected, though theoretically by a rare recombination a new gene may be constituted and starch types changed. It is considered probable that the capacity to accumulate protein is linked to the starch structure, because in the rice grain the protein is not restricted to the pericarp and embryo, though the concentration is more in these structures. The losses in protein on milling and polishing the grain are mainly due to loss of embryo and partly to loss of bran. It can be easily seen that the "waxy" type of grain is never translucent, but is whitish and this opacity is due to air spaces accompanying drying and shrinking between grain filling and harvest. The waxy endosperm is considered to be "permissive" of protein accumulation, and inferentially the genetic loci concerned with synthesis of the protein are different. There is a hope that in breeding from "waxy" parents, a segregant parallel to "Opaque 2" the high lysine maize can be isolated.

There is one other approach to breed high protein rices and this is to evolve fertile productive autotetraploids. Experiments in this Institute have shown that in tetraploids the protein is more than in the corresponding diploids and that by hybridising different homozygous tetraploids the inherent semisterility can be reduced. However the tetraploid cultures now being grown in this Institute give grains having 10–12% protein only even when heavily manured. The production of new tetraploids having higher protein content and also good productivity is likely to be arduous.

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4. Swaminathan, M. S., *Farmer and Parliament*, 1968, 3, 10.