Rice Research in Madras.*

By K. Ramiah.

INDIA including Burma occupies a very predominant position with regard to world's production of rice, its share being 33 million tons out of a total of 59 millions. The share of Madras in this is roughly a little over 5 millions. So far as trade in rice is concerned, it is Burma because of its big production and meagre population that figures most prominently. The most important feature of rice cultivation is the profuse water supply it requires. It is grown essentially under swamp conditions throughout the world.

Rice is one of the earliest crops known to man. Regarding its place of origin recent researches have shown that S.-E. Asia, either Indo-China or India, is the original home. In an ancient Chinese work, nearly 5,000 years old, rice is mentioned as one of the principal plants nourishing the country. Ancient Egyptians did not know of rice, nor is it mentioned in the old testament. The Asiatic origin of rice is confirmed by the multifariousness of the varietal material in China, Indo-China and India. Rice got into Europe only by 300 B.C. introduced by Alexander from India. Due to the antiquity and the ages through which it has been in cultivation there is a profusion of varieties. It is stated that there are over 2,000 varieties in Asia alone and the Coimbatore collections that have been gradually accumulating have now come to nearly a 1,000. The characters, both morphological and physiological, in which the varieties differ from each other are extremely varied that it is impossible to adopt a perfect system of classification. The life duration of the plant may vary anything from 90 days up to 8 months and this again is subject to the influence of the locality in which it is grown.

A systematic study of rice begun in Madras in 1914, covers all aspects, genetics, morphology, physiology, agronomy and recently cytology as well. The three well-known methods of crop improvement work have been practised, *viz.*, introduction, selection and hybridisation. Except one or two instances, the question of introduction has not been attended with much success as the question is, to a large extent, dependent upon the particular requirements of particular tracts.

The pure line selection, the main underlying principle of which consists in that the merits of an individual are to be judged by the performance of its progeny, has been very fruitful of results. Already ten strains have been evolved in Coimbatore which are under distribution to the people in different parts of the province. The area under these improved strains can now be safely reckoned in several hundreds of thousand acres. These strains besides giving yield increases varying from 10–20% are also found to possess some useful ancillary characters like good quality rice, high percentage of rice to unhusked grain, resistance to diseases, etc. As an instance of the wide popularity of one of the Coimbatore strains, mention may be made of GEB 24 which is grown practically all over the province. Even in Mysore where it was first introduced in 1924–25, it is now considered the most popular variety occupying 30—40 thousand acres.

The selection work has, however, one important limitation in that we cannot be sure that a strain doing well in one centre under a particular set of agricultural and climatological conditions will behave equally so under a different set of conditions. So the expansion of the Coimbatore work took the shape of the opening of a number of sub-stations, one in each of the important rice tracts of the province, so that the local problems and the local varieties could be tackled there. The first sub-station opened in Aduturai for the Tanjore district, has already issued 11 strains, and at a very modest estimate it can be said that more than half the area of this district is now grown with these improved strains. The second station opened in Maruteru has issued 8 strains suitable for the Kistna and Godavari districts. It is only a question of time before strains are issued from two other stations, one in Pattambi for Malabar, and the other at Berhampore for Ganjam, the two districts which record the poorest rice yields in the province.

Rice plant just like any other organism is influenced by the environment, soil and climate, in which it is grown and hence probably the widely divergent acre yields obtained in the different rice-producing countries of the world. India occupies an unfavourable position with regard to acre yields when compared to countries like Spain, Japan and Italy though among the provinces within India, Madras is definitely the best. That intensive methods of cultivation, manuring and growing of strains all combined, can increase the yields even in Madras has been exemplified in the Coimbatore Central Farm where the average acre yields have been increased to nearly 4,000 lb., nearly double those of 10 years ago.

The next line of improvement is by hybridisation which attempts at synthesising in one variety certain desirable characteristics observed in two or more varieties, by undertaking artificial crossing among them, and picking out from the resulting varying progeny those types showing the desirable combinations. The success of this work depends upon the correct choice of the parents and a knowledge of the genetics of the particular characters sought after. The principle of inheritance is based on the famous "Mendel's Laws". The study of cytology, *i.e.*, the changes in the cell contents, which has made such great progress in the last two decades has had a phenomenal effect on the study of genetics. It was just 25 years ago that a definite connection was actually established between the behaviour of chromosomes, the dark staining minute bodies in the nucleus of the cell, and the laws of heredity. We are indebted to Professor Morgan and his colleagues in America who, with their classical work on the fruit fly, *Drosophila*, have been mainly responsible for this advance now recognised as the "chromosome theory of heredity". His work has led to several important modifications in the "Mendel's Laws", and has given us the conception how two characters in particular instances always go together and occasionally behave independently, known in

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technical language as "Linkage" and "Crossing-over" respectively.

Both the cultivated and the wild species of rice so far examined contain 12 pairs of chromosomes and according to the chromosome theory all the inherited characters must fall into 12 groups. We have so far studied the inheritance of nearly 100 characters and we have been able broadly to account for nearly 8 groups and the detailed inter-relationships amongst the members of each group have yet to be worked out.

That very striking results of improvement have not been effected in spite of the fact that artificial hybridisation has been practised in Coimbatore for the last several years is due to the fact that our knowledge about the complicated inheritance of several quantitative characters, which are the ones directly related to yield, is only gradually accumulating. Mention can, however, be made of two instances where hybridisation has met with success. There is now one strain issued from Aduturai (Adt. 8), a progeny of a hybrid made on the station, which while giving the same yield or even slightly more than Adt. 2, one of the parents, comes to maturity a fortnight earlier, which is a big gain as it can be more successfully grown than Adt. 2 wherever there is scarcity of water towards the end of the season.

The Rice plant is subject to a serious fungus disease, *Piricularia oryzae*, and when this breaks out in an epidemic form, practically the whole crop is lost. In the cases of diseases of agricultural crops, curative methods are practically out of question and the breeding of resistant types is the only weapon available with the breeder. Special crosses were made between *korangu samba*, an important variety of the Tanjore district and which is specially subject to this disease and two of the Coimbatore strains, GEB. 24 and Co. 4, which are found to be resistant. This work is now nearly 8 years old and has come to the stage when a few of the progenies from the first cross are found to be resistant to the disease besides giving a very much bigger yield than the susceptible variety.

The question of improvement does not cease with the evolution of strains, either direct selections or selections from hybrid progenies. There is another aspect of improvement, that due to 'nurture' as different from 'nature' involved in breeding. The yield which is the main consideration, is the end expression of all the vital processes of the plant throughout life, and to study yield, we have to make an analysis of the components of yield and how they are modified by the environment the plant is placed in. The study of the developmental phases of the rice plant has received considerable attention in recent years. One of the important developmental phases is tillering, or the production of side shoots. This phase goes on continuously for about 6 weeks after transplanting, depending upon the age of the variety, followed by a decline caused by the late tillers dying off, so that the number of final ears formed in each plant is only 50—70% of the total tillers produced. The production of the ears has a direct relation to tillering. In early varieties, under 4 months in duration, the formation of the rudimentary ear commences about two weeks before the maximum tillering phase is reached; in medium duration varieties, say 5 months, the two events synchronise; and in long duration varieties, 6 months and above, there is an apparent quiescent period of about 6 weeks after the maximum tillering phase is reached. These different developmental phases have a bearing on the cultural and manurial practices. One of the cultural practices involved is the spacing given to the plant at transplanting time, the more the spacing the greater is the number of tillers produced, but there is an optimum for each variety and each locality beyond which increased tillering induced by extra spacing cannot compensate for the reduction in the total number of tillers per unit area. In the early stages of the crop, spacing has even a greater effect on tillering than manuring.

The time at which manuring has its greatest value depends upon which stages in the plant's development are most intimately connected with yield, and which are most influenced by differences of manuring and soil fertility. The question whether the available manure should be given to the seed-beds or to the transplant field has been examined and it is found that manuring of the field rather than the seed-beds is more desirable. The application of a quick-acting manure like ammonium sulphate to the crop has been experimented with, and it has been found that it must be applied immediately after transplanting for a short duration variety while it is advantageous to postpone the application, up to 2 months after transplanting, for a long duration crop.

Hitherto the problem of breeding has been mainly confined to quantity, rather than to quality because quality does not come in at all in the polished rice as is generally consumed in the country. The antineuretic vitamin B_1, the proteins, and oil contained in rice are all to be found in the germ or embryo and the seed coat or bran which gets completely removed in the polishing processes. That varieties differ from each other with regard to the thickness of the seed coat has become evident from the histological study of the grain made in Coimbatore. Some of the coloured rices are found to have thicker bran than the white rices. In the interest of better health and nutrition when the craze for the highly polished white rices disappears, an unpolished rice with a thicker bran must be certainly more nutritious than one with a thinner coat, and the problem of producing rices with a thicker coat combined with yield is under investigation. Besides the vitamins and proteins there are certain other aspects concerned with rice nutrition about which little is so far known. These are concerned with the problem of storage and the changes taking place during storing and in the conversion of raw into par-boiled rice.

Coming to the recent developments in the study of the rice plant, the determining of the several linkage groups and the inter-relationship among the characters of each group is being pushed through by making suitable crosses between selected pure lines whose genetic constitutions are known. Though crosses are also being done with a view to synthesise useful characters in one type, the question of linkage often sets up a limitation to our getting any and every type of combination of characters. There have been several instances where the crosses failed to give useful results with regard to the combination of valuable characters like tillering, non-lodging nature of the straw, density of panicle, etc. In addition to the problem of linkage there were several cases where the progenies of crosses began to throw in the F_2s and later

generations various semi-lethal chlorophyll deficient types and completely lethal albinos though these were not present in the parents themselves.

In addition to the above, several cases of sterility where the spikelets remain chaffy without developing any grain are also met with. The chief manifestation of such spikelet sterility is the occurrence of non-viable pollen or male gametes. Cytological studies are able to connect the sterility with the peculiar behaviour of the chromosomes. Usually in interspecies crosses involving different numbers of chromosome the sterility is caused by the presence of these unpaired univalent chromosomes. This, however, does not apply to rice as all the species of Oryza so far examined have the same chromosome number. Sterility in this case must therefore be due to the different genic constitution of the chromosome sets. This is the characteristic of crosses between different geographical races.

Several cases of chromosome irregularities have been met with. There have been one or two instances where due to a stimulus, seed has formed without the fusion of the male gamete with the egg, the result being the plant arising from it contains only half the chromosome set, *haploid*. This plant is very much reduced in size, and completely sterile. Such a plant is found to set seed very occasionally due probably to the chance union of the haploid complement of chromosomes. The plants arising from such seeds should be absolutely homozygous.

Plants have also occurred with three sets of chromosomes instead of the usual two, *triploids*, due to the union of a male gamete with an unreduced egg. Such a plant is also sterile because of the uneven number of chromosomes but it occasionally sets seed giving rise to *polysomics*, where, in addition to the diploid chromosome sets, there are one or more extra chromosomes. Plants with $2n + 1$, $2n + 2$, and $2n + 3$ chromosomes have been obtained, the increase in the number of extra chromosomes being associated with corresponding decreases in stature, vigour, etc., of the plants containing them.

Recent researches in some plants have led to the production by artificial means of *tetraploids*, where, instead of the two sets of chromosomes, there are four. These that arise by the duplication of the chromosomes, are usually bigger in stature, more vigorous than the *diploids*, and form a new species altogether. These have been produced from hybrids of different species which though sterile become fertile by the doubling of the chromosome set brought about by suppression of the cytoplasmic division at meiosis. After repeated attempts a successful cross has been obtained between two species of Oryza, *O. sativa* and *O. latifolia*, and the production of tetraploids from this hybrid is being attempted. This attempt, if successful, should prove extremely interesting.

In addition to changes that occur in the whole chromosome sets as in the cases mentioned above, there can also be changes in the genic make-up of the chromosomes, such changes being termed point or gene mutations. Treatment of the plants with X-rays has been found to be a prolific source for producing such changes artificially. The work of subjecting rice to X-rays has already begun in Coimbatore. Some of the pure lines have, as a result of the X-ray treatments, thrown dwarfs, albinos, chlorophyll deficient types, etc., which usually occur in the progenies of definite crosses. The plants resulting from X-rayed seed are found to be sterile and their cytological studies are proving extremely interesting. Among other chromosomal disturbances chromosome rings are found to occur in the meiosis obviously due to reciprocal translocation of parts of non-homologous chromosomes.

Plant breeding as a branch of agricultural science stands for producing new crops or plants, the introduction of which should bring a greater return to the cultivator. It is well to recognise that the outlook of the breeder is thus conditioned by restrictions from which pure science, as a branch of scholarship, should be kept free. As the previous narrative has shown, rice breeding work in Madras has, by the evolution of a large number of superior strains and their cultivation by the ryots, materially increased the production and hence the return to the grower, but due, unfortunately, to the present slump in the rice market, the position of the Madras rice-grower is anything but bright. Prices have gone down terribly and in some cases even to the extent of 200% over the prevailing prices 3 or 4 years ago. Such a fall cannot easily be accounted for. At any rate over-production is certainly not yet a contributory cause. It is hoped that the enquiries of the special officer recently appointed for the purpose will throw light on the problem and result in finding ways and means of bringing some relief to the rice cultivator.

Optical Technology.*

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IN recent years the sciences have certainly reached a high state of development in India. The original contributions, reckoned either by their quality or quantity, constitute a record of which we could be proud. But when one considers the extent of knowledge of a practical character that prevails in the country which is necessary for the manufacture of apparatus with which these researches are carried out, one will make rather dismal discoveries. Not only is there a complete lack of instrumental skill but there is also a sort of contempt for the acquisition of that knowledge and skill. There is also a tendency to regard such knowledge and skill as purely mechanical and unscientific. I do consider this tendency highly detrimental to our material progress; the science of Physics comprises also applied and industrial aspects capable of extensive commercial application and it is high time that we concentrate and direct our scientific knowledge to this much-neglected direction and produce results

* Text of a paper read before the Bangalore Easter Science Congress, 1934.