Suggestions for Research on Coconuts

By

J. B. S. HALDANE

Indian Statistical Institute, Calcutta-35

THIS article demands an apology. I am ignorant of the details of coconut culture, and have only spent a few hours at the Research Stations at Kayangulam and Kasaragod. I have therefore no doubt that many of my suggestions will be impracticable for different reasons. However they may stimulate others to work along lines similar to those which I have suggested, but more likely to be successful.

MIXED CROPPING

The soil beneath a coconut grove is capable of bearing another crop. This may be a "green manure" plant such as *Glyricidia* whose sole function is to aid the palm trees. If however the plants grown under the trees are to be harvested, I think one should consider three quite distinct questions.

1. Is it economically advantageous to grow x under coconut palms, not necessarily in every year, under existing conditions of manuring? In Kerala x might be a nutritious crop such as tapioca, or one such as cloves, black pepper or pan, the last of which demands shade in any case. In West Bengal pine-apples and arrowroot are often grown.

2. If it is found that such double cropping exhausts the soil and reduces the yield of coconuts under existing conditions, does it do so if chemical fertilizers are applied intensively? If so it may be an economic proposition ten years hence, when India's output of fertilisers has been greatly increased. A knowledge of such possibilities will greatly help economic planning.

3. Is it practicable, if there is a threat of famine, to plant an important and quickly growing food source which in Kerala would probably be tapioca, under coconut palms, without immediately reducing their yield? Such planting could be justified as an emergency measure, even if it would exhaust the soil and lower yields grossly if continued for a number of years.

These questions would of course have to be answered for several different types of soil in Kerala, and later, no doubt, in other states. It is natural enough that stations charged with research on coconuts should concentrate on the question of how to get the highest yield of nuts, or of oil, per acre per year. But the questions asked above are also important, both in the public interest and in that of the cultivators.

BEES

I understand that the relative importance of wind and insect pollination of coconut palms is a matter of controversy. This suggests that in some circumstances insects may be important. It is very easy to decide this matter experimentally. They are extremely important for English fruit crops. Indeed, it has been stated that in England the value of bees in enhancing the yield of fruit trees is about three times that of the honey which they produce.

Their value, if any, in Kerala, could readily be discovered. I understand that bee-keeping is quite an important occupation in Coorg, but that bees often die in the hot weather in the plains, and may migrate uphill. It might therefore be necessary to take the bees into the hills during a part of the year. Fortunately in Kerala this would not be a long journey. The honey produced from the palm trees would be a clear addition to our food supply, but unless there was also a gain in coconut yield it might not pay for the labour and materials needed.

Linked up with this are two other questions. Would the insecticides used on coconut palm trees and other crops in the neighbourhood kill hive bees? And do they now kill wild bees and other insects to such an extent as to lower the frequency of successful pollination, and thus the yield of coconuts? It is likely that the answer to these questions may be very different in different areas. For example sea spray, which certainly does not harm coconut trees, may have a considerable effect on insects.

PATERNAL INFLUENCES ON NUTS

Before I consider the possibilities of breeding, I should like to raise the question of the influence of the pollen parent on the coconut. The cultivated plant which from this point of view, resembles the coconut palm most closely, and which has been well studied, is maize. Here, as in coconuts, the endosperm is the most important tissue from the human point of view. Although its nuclei contain two maternal sets of chromosomes and only one set of paternal chromosomes these latter can have an important influence on the carotene content, the type of carbohydrate, the content of several vitamins, and the anthocyanin coloration.

It should be possible to compare the size, oil content, and perhaps other characters of the nuts borne on the same tree after using pollen from two different "male" parents. It would be worth using as one pollen parent a tree with poor oil yield to give as high a contrast as possible with one of the desired type.

The result of such experiments might have no immediate bearing on breeding, however it would at least tell us something about the genetical determination of the characters of the actual nut. There is another reason for making such experiments. Work on the genetics of the coconut must be very tedious. One may expect, in a life-time, to get information of the type which one obtains in a month with *Drosophila melanogaster*, for example evidence that an abnormality is recessive or that two genes are or are not linked. Unless the workers concerned are allowed to work on other genetical problems they will have to concentrate on other sides of coconut biology, and will get no experience of genetics. Ideally I believe they should be encouraged to breed annual plants. If not they could at least attack the question of the effect of pollen on the nuts.

There is however a possibility that hybrid vigour may show in the nuts derived by cross-pollination, since hybrid vigour in some species is largely due to increased seed weight. If so it is possible that a mixed plantation may produce a better crop than either of two breeds when grown alone.

VEGETATIVE PROPAGATION

If it is possible to propagate a plant vegetatively, the plants derived from a single seedling by vegetative propagation form a clone whose members, in a constant environment, resemble one another very closely. Examples are named varieties of potatoes, roses, mangoes, and seedless bananas. Many new clones of tapioca have recently been produced in Kerala. Holttum (1955), Harland (1957) and perhaps others, have pointed out that if coconut palms could be propagated vegetatively, by planting cuttings, or by grafting on to seedlings, trees of high yield could be multiplied indefinitely. There are considerable differences in the yield of trees growing under very similar conditions. If one could propagate the best 1 per cent. of trees in Kerala vegetatively there would be a very considerable increase in yield, though I have failed to discover data which would permit its estimation.

No method has yet been invented to permit the vegetative propagation of a given tree, though it could be rejuvenated and, perhaps, grown for another century or longer, by inducing aerial roots, sawing through the trunk below them and replanting (Menon, Davis, Anandan and Pillai, 1955). It would surely be worth doing this systematically to trees of exceptionally high yield, if only to preserve them for future breeding. However, Davis (1950, 1956) reports branching in exceptional trees. If a tree can be propagated vegetatively, for whatever reason, it is of value in manurial trials even if its yield is low.

For the yields of two or more members of a clone in the same environment are probably very close. If so the differences between their yields in different environments are mainly due to the environmental differences. Bonnier (1948) and his colleagues found that by using pairs of monozygotic twins, he could reduce the number of calves needed in an experiment on the effect of diet on milk yield to about one twentieth of that required when comparisons were made between calves from the same herd. The use of vegetatively propagated trees may therefore allow far more trials to be made than are at present possible.

STATISTICS

I had hoped, on visiting Kerala, to obtain statistics, say, on the yield of copra from each of several hundred trees over a period of ten years. I was unable to obtain such figures even for the numbers of nuts. It appears that they exist for the Indian West Coast breed, but have not been adequately analysed. If nut number is counted, one of the first needs is to discover for how many years one must do so to get a reasonable estimate of a tree's performance in later years. It may be found that some trees reach their maximal yield much earlier than others. Correlation analysis should be done in two distinct ways. On the one hand if data on the yields of, say, 100 trees over 15 years were available, the technique of serial correlation applied to each tree separately would presumably demonstrate a negative correlation between yields in successive years for some of the trees, which only fruit well in alternate years. It is important to know if this is a sharply defined character, how it is inherited, and whether it can be overcome by the use of fertilizers. Secondly correlations between the yields of trees in a group in different years should be worked out. Perhaps regression analysis would be better. The kind of question to be asked is this. "How accurately can we predict the yield of a tree in 1959 from a knowledge of its yields in the years 1953 to 1957 inclusive? Is there any serious advantage in using figures over ten rather than five years, or would less than five be sufficient?"

If we know the distribution of (say) ten-year yields for a group of trees we can ask what would be the increase of yield if we could arrange, by breeding, husbandry, or a combination, to get a group of trees whose average yield was as high as that of the best ten per cent, of the group. This, I think, gives us an idea of what might be attained within thirty years or so. Until members of a clone have been compared, we shall only be able to guess at how much of the observed variation is genetically determined.

Meanwhile statistics on the oil yield of individual trees are much to be desired. We have a precisely similar problem in the case of cows. Here the milk yield and butter percentage vary more or less independently, and both are genetically determined to some extent. But the butter fat percentage seems to be much less dependent on diet than the total yield.

Only when we can assess the value of an individual tree by quantitative methods can we hope to get the utmost value from a programme of improvement by selective breeding.

FORMAL GENETICS

In most domestic animals and plants a number of characters are known which are inherited according to Mendel's laws, or some slight modification of them. Such characters are rarely of great economic importance, except that deviations from the norm of a breed are usually undesired. However their study has more than paid for itself. Such characters should be studied in the coconut. Results obtained at Kasaragod, for example, were compatible with the view that the variety *spicata* is dominant over the normal, though they certainly did not prove it.

One point is perhaps worth

making. A variety which is a "freak" in most environments may be most valuable in others. For example small-combed poultry are bred in southern India to lessen the danger of bleeding during cock fights. The genes which reduce the comb size in these breeds have been transferred to high laying breeds to avoid injury to combs by frost, both in U. S. S. R. and Canada Genes which lessen the feathering characterise "fancy" breeds in temperate climates, but are found in tropical breeds which are kept entirely for egg and meat production. It is possible that some variants may prove to be particularly valuable in unfavourable soils or resistant to particular infections.

In the study of formal genetics two things are essential. First, the paternity of every plant must be known with certainty. Secondly all the progeny of a cross or a self-fertilization must be grown. If seedlings which do not grow rapidly or are in other respects below the usual form are discarded, formal genetics cannot be investigated.

SELF-FERTILIZATION

There are two rather distinct reasons why the effects of self-fertilization should be studied. In the first place the fact that it is known to depress vigour, as shown by Patel (1937) and others makes it highly probable that if fairly homozygous lines were produced by, say, three generations of self-fertilization, the progeny of a first cross between two such lines would not merely show greater vigour than either parent, but also more than the average random bred plant. This is sufficiently often so in maize to make this method economically valuable. Secondly, individual plants of an outbred species like the coconut are likely to be heterozygous for a variety of recessive characters Most of these will only be of interest for formal genetics, but some may be of economic value.

However, by rejecting the slowly growing seedlings the majority of these recessives will be lost; and, what is more serious, the relatively homozygous plants, whose crossing might be economically valuable, will probably be lost too. The pure lines of maize whose crossing has proved of such value in the U. S. A. are mostly miserable looking plants which would be weeded out in any selection programme. It thus seems that so far the products of self-fertilization of coconuts are likely to be of little economic value; but this need not be the case in future if attention is paid to the principles of genetics.

SELECTION

Until more work has been done to assess the performance of individual trees and to follow up the yield of trees, the yield of whose mother and father are both known, I am not convinced that we need accept the conclusions of Pieris (1937) and others as to the inefficacy of parent selection, which are based on selection of seed parents only. However, the heritability of yield is probably fairly low. Gangolly, Satyabalan and Pandalai (1957) seem to follow Pieris in placing more reliance on seedling selection. In view of the findings in Ceylon it would seem that parent selection may be more efficient in one population and seedling selection in another. It therefore seems desirable to confirm the efficiency of seedling selection under Indian conditions, and measure it, at least roughly, by growing say 30 seedlings which would have been rejected, for long enough to estimate their yields.

Harland (1957) stresses the possibility of finding trees most of whose progeny have a high yield. The difficulty of such a programme lies in the very large number of progeny which must be tested before such a "prepotent" tree is identified with near certainty. I am glad to see that Harland's suggestion is being taken seriously in Kerala. It seems to me premature to lay down a programme of selection until the data which have, apparently, been collected, are subjected to statistical analysis, and set out in such a form that they can be examined by geneticists with experience of organisms in which generations are shorter.

I think that a sharp distinction should be made between two programmes. On the one hand selection of a rough and ready kind may be practised without artificial pollination. On the other, a programme of a more scientific character, based on artificial pollination and including some breeding from trees of low yield, might be carried out at one or more stations.

THE DWARF PALM

Gangolly, Satyabalan and Pandalai (1957) summarize the existing knowledge of the performance of dwarf palms and their hybrids with tall. This does not include any information as to the genetic determination of dwarfness. I am told that some progeny of hybrids are to be seen at

Nileshwar, but it does not seem to be known whether the character of dwarfness is mainly due to a single gene (which we may provisionally call D, since the heterozygotes Dd are intermediate between DD, dwarf, and dd, tall, in some characters). There seems to be no doubt that in some important characters the hybrids are superior to their tall parents. If dwarfness is mainly due to a single gene the following question arises. Are the hybrids superior mainly because they are Dd, or is this superiority due to genes at many loci? If the former hypothesis is correct, then Dd X dd or dd X Dd should give about equal numbers of Dd and dd, and the former should be superior from an economic point of view. It would then be possible to introduce D into various races of Indian coconut. Until the necessary genetical information is obtained one cannot make further detailed suggestions.

FOREIGN BREEDS

A number of nuts of foreign breeds have been planted at Kasaragod, and results are awaited. It is perhaps unlikely, though not impossible, that any of the trees derived from them will prove superior to the local variety. It is much more likely that first generation hybrids of these breeds, either with Indian breeds, or with one another, may prove to be of value. Here again no sure conclusions can be reached unless the paternity of each plant is known. The fact that trees of a given breed do not do particularly well in Kerala does not prove that hybrids derived from them may not do so. If the hybrids are thought desirable it may or may not be found that later generations derived either from back-crossing or from the inter-crossing of hybrids, will be of value. But it is most important that hybrid trees should not be discarded because they appear to be of little value. The desirable characters of two breeds may disappear in the first cross, but in later generations plants may appear which combine them or show new desirable characters. It will be seen that we have to ask a number of distinct questions, that the answer to one gives little guidance concerning the answer to another, and that experiments should be planned to answer as many as possible.

CONCLUSIONS

I must thank Dr. P. J. Gregory for permitting me to visit Kayangulam and Kasaragod. I am fully aware that research of any kind on coconuts must be a slow process at best. Just for this reason the methods used must be as efficient as possible. If an experiment on *Drosophila* can be completed in 20 weeks rather than 30, it may not be worth while taking the trouble needed to accelerate it. It is worth taking a lot of trouble to reduce the time needed to find out something about coconuts from 30 years to 20. This is likely to be achieved by the fullest possible use of statistical and genetical techniques. I have also suggested some other questions whose solution should not be too difficult and which might be of economic value.

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[Work on breeding of coconuts was commenced in India at Kasar agod on a very small scale since 1922. In 1937, under a research scheme financed by the Indian Council of Agricultural Research, some further breeding work was undertaken. These were necessarily of a preliminary and exploratory nature. In 1947 the Indian Central Coconut Committee took over the Kasaragod Station and extended it by acquiring 100 additional acres of land and also established a separate section there for breeding work. The work done till that time was reviewed and in 1951 plans were drawn up to study in greater detail the different aspects of coconut breeding work such as selection, hybridisation between T x D and exotic varieties, optimum parental combination in T x D, study of mother palms and their progenies etc. The material obtained from these different studies have been and are being planted in the field for study in detail their performance. Coconut being a perennial crop which takes about 20 years to come to its normal bearing period it would naturally take a fairly long time for results to be obtained. The suggestions made by Prof. Haldane have been noted by the research staff of the Indian Central Coconut Committee and will be given due consideration in planning future work. — *Ed. I. C. J.*]