

SOME DIFFICULTIES IN THE IMPROVEMENT OF INDIAN SUGARCANES.

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(Plates XIII—XVI and 3 Text-figures.)

THE need for improving the class of sugarcane grown in India has long been recognised, and fitful efforts in this direction have been made during the last hundred years or more. These efforts have, almost uniformly, resulted in failure, chiefly owing to a lack of appreciation of the factors involved. The subject has, however, again forced itself on the attention of Government because of the steadily increasing imports into India of Java sugar. There is, in India, a much larger acreage under sugarcane than in any other country and it has been not unreasonably maintained that there must be something wrong if it cannot supply its own demand for sugar. The produce of the fields is, however, so low that it is quite insufficient to meet the demands of the growing population.

In approaching the problem anew, it has been considered advisable to make a closer study of the canes themselves and the conditions of soil and climate under which they grow than appears to have been done before, and certain intrinsic difficulties have been met with which may very easily account for former failures. Before considering these it will be well to indicate briefly the conditions referred to. For the sake of conciseness, it is convenient to divide the Indian sugarcane area into two parts, a northern and a southern, as indicated in the accompanying sketch-map. The southern portion, consisting of parts of Madras, Mysore and Bombay, is on the whole well suited for sugarcane growing. It is wholly within the tropics, the temperature is uniformly high throughout the year and, in many places, the soil is good. The rainfall is, however, of such a nature that irrigation is needed to supplement it. India is not blessed with the well-distributed rainfall of tropical islands

and, almost everywhere, there are long periods of drought, often extending for four or five months at a time. Where temperature and soil are suitable, moistness is found to be a limiting factor. In the north, the

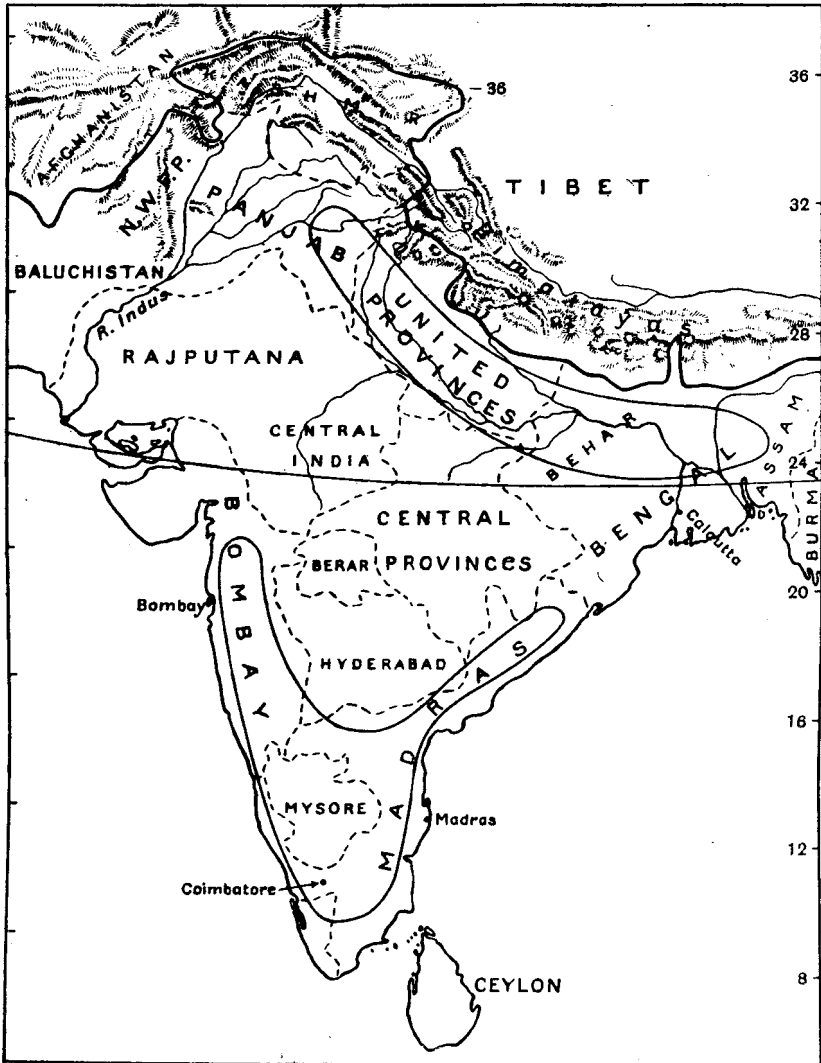


Fig. 1.

main sugarcane tract extends from Assam to the Panjab, along the foot of the Himalayas, a distance of over 1000 miles. On comparing the acreage of these northern and southern regions, it is found that the

cane is much more thickly planted in the former, so that vastly the greater part of the crop is grown in this northern region, constituting an aggregate of something like 4000 square miles. This is entirely outside the tropics. Moisture is adequate, by rain near the hills and a complete network of canals farther south where, however, paddy is no longer a serious rival. The soil is easily permeable, deep and rich, but the total amount of warmth and especially the length of the growing period are insufficient. The continuance of suitable high temperature is the limiting factor here.

This difference in climate between the northern or continental portion and the southern or peninsular has a marked influence on the character of canes grown in the two regions. While the field canes in Southern India are often comparable with those of tropical islands in thickness and vigour, those of North India are much thinner, more fibrous and much less productive of sugar in the crop. The canefields look very different in the two tracts, as may be gathered from the photographs, those in Bengal standing intermediate between the extremes of Madras and the Panjab. And, when the canes are carefully examined, they are generally so unlike in morphological characters and habit that it is worth while considering whether they have been derived from the same ancestral species of *Saccharum*. These differences in climate and character of the canes have a pronounced effect upon the whole course of cultivation in the field and, while the cultivation of sugarcane in the south is intensive and costly, the crop in the Gangetic plain has little attention paid to it.

Judging by the periodic returns issued by Government, the area under sugarcane remains more or less stationary, but, on the other hand, the population is rapidly increasing. It is still doubtful whether the diminution in poppy-growing will bring much more land under sugarcane, and although there are indications of extension in some localities, there is no immediate prospect of any great increase in the area under this crop. Improvement in production must therefore take the line of increasing the yield per acre. With this object in view, a small department has recently been opened by the Indian Government for the general study of the sugarcanes of the country. There are, of course, various ways in which the problem may be approached. Leaving aside the whole question of improvement in agricultural practice, which is now receiving a good deal of attention, the canes are seen to be obviously inferior in character in North India, and it is natural to consider whether success may not be obtained most rapidly and

economically by replacing them with better kinds. There are four ways in which this may be attempted:—

(1) *The introduction of exotic canes which have proved of value elsewhere.* This method has been the main line followed for many years all over India, from Madras to Peshawar. Thick, tropical canes, the relics of successive importations, are everywhere met with. But it is generally found that these thick canes have not time to mature in the north during the short, hot, moist period. They sometimes grow surprisingly well and are full of juice, but the ripening process by which the glucose is changed to crystallisable sucrose is arrested and, although extensively used as fruit and eaten raw, these thick exotic canes are generally useless for the manufacture of sugar. It is possible that certain early maturing varieties may still be met with, or that changes in treatment may lead to improvement along this line, and this is not being lost sight of, but we have the advantage of actual demonstration of their behaviour all over the country and the prospect of success is not encouraging.

(2) *The transfer of canes from one part of India to another.* This method of improvement is well known to the cultivator. He is not only accustomed to the trial of new varieties valued elsewhere, but is acquainted with the advantage of occasional change of seed in the same variety. Exchanges of varieties are being actively carried on by the Agricultural departments of the various Provinces and occasional advantage accrues from this. Collections of different varieties of sugarcane growing together are a constant feature on local farms. The fine new canes introduced into Madras through the Samalkota farm are now to be met with in every part of India, even extending to the North-West Frontier Province. But success along this line is limited and, in the main, the introduced kinds cannot hold their own against the best local kinds, the latter themselves being the outcome of centuries of selection by the cultivators.

(3) *The improvement of local canes by selection and the observation of sports.* This method has perhaps hardly received the attention during recent years that it undoubtedly deserves, but there are special difficulties in the way with a crop that can only be finally judged after it has passed through the mill and been chemically analysed. The sugarcane has, from time immemorial, been propagated by cuttings, and it is difficult to determine whether chance variations in growth are or are not due to better local treatment or feeding.

(4) *The production of seedlings.* This has been tried many times

in India, but in the past always unsuccessfully. The experiments have not always been conducted very carefully, and on the founding of the new department it was decided to examine the matter afresh and try to determine the cause of failure in the face of the successful results obtained in Java, the West Indies and elsewhere. The solution of the problem turned out to be remarkably simple. Almost all the experiments were made in North India and it transpires that the stamens do not mature and pollen is not formed in the cane flowers there. A cursory glance showed that this was not the case in South India, and in the Government farm opened at Coimbatore in the Madras Presidency some 40,000 seedlings have been raised during the past two years.

Problem 1. During the short time that the cane-breeding station has been in existence, a very important step in advance has been taken and the first problem, that of obtaining seedlings, has been solved. But in considering the ultimate aim of the station more carefully, a number of difficulties have cropped up and it is the intention in the present paper to detail some of these further problems, in the hope that help may be available from the great body of readers interested in plant-breeding.

Problem 2. Most, if not all, of the difficulties in procuring suitable cane seedlings have arisen from the fact that the flowering is irregular—in fact, comparatively rare. If a cane flowers and we obtain seedlings from it, we cannot count on these seedlings flowering. We have no means at present of inducing the canes we are most interested in to flower. Control of the flowering is the second difficulty we have encountered.

Arrowing of the cane, as the production of the inflorescence is called, is comparatively rare in North India, but occasionally it occurs over large areas. It is viewed with alarm in certain regions, and there appears to be some reason for connecting it with the weather and especially with a failure of the normal rains. Flowering of the sugarcane appears to be commoner in years of drought, but details on this point are not yet available. In Mysore and Coimbatore, typically dry tracts, flowering is common, and on the other Madras farms where sugarcane is grown, in Malabar, Godavari and South Arcot, the amount of flowering seems to vary inversely with the moistness of the climate. On the other hand, it is a common belief among Coimbatore cultivators that arrowing is most frequent in water-logged conditions of the roots. Experiments are now being conducted on the farm with different soils and different amounts of moisture to see if any effect is produced,

for it is felt that, until some control of flowering is obtained, working along Mendelian lines is more or less out of the question. If the supposition of the Coimbatore ryots is correct, it would seem to indicate that flowering ensues whenever the flow of sap is interfered with, whether by the paucity of water or the unhealthiness of the root system.

Problem 3. Another matter which has attracted our attention is that there appears to be a very close relation between richness and purity of juice and vigour of growth. The first requisite in a seedling cane is a high percentage of sucrose and purity of juice, but the total quantity of sugar is what is aimed at in the field, and this will obviously depend upon vigour of growth and the number and size of millable canes in the crop. The first year's seedlings when analysed and weighed showed a markedly converse relation between purity and vigour. The smallest and most meagre plants had the richest juice and those seedlings which were distinguished by the abnormal vigour of seedlings were very poor indeed in sucrose content. Richness and purity, if dependent on lack of vigour, may to all intents and purposes be regarded as a diseased condition and, if so, must be very carefully distinguished from purity and richness which are inherent and varietal. Among my colleagues, Mr Parnell has drawn my attention to a similar relation in indigo seedlings between meagre leaf production and richness in indigotin, and Mr Anstead states that, in analyses made by him of individual rubber trees in South Indian plantations, the latex richest in rubber was obtained from poorly grown or stunted trees.

Problem 4. One important line of work in the cane-breeding station is the selection of suitable parents and inducing them to flower together. But, even if we are successful in this, we are confronted with another serious difficulty. How shall we determine if seedlings obtained are really crosses? We can approach this problem either directly or indirectly. In the first place we may actually cross the two varieties with scientific precautions against self-fertilisation. This has been successfully carried out in Barbados for several years. In Coimbatore there are special difficulties in the way. The bulk of the canes arrow during the heart of the north-east monsoon, a period of violent winds and torrential rains. As the long stalk of the inflorescence (arrow) is very easily damaged and the slightest bend appears to cause it to wither, we have to erect over each arrow a gallows-like support, with a hanging iron cage covered with muslin—much after the plan adopted in Java. The difficulties in crossing such inflorescences can be readily imagined. There are an enormous number of flowers on each arrow and the male

and female organs mature at practically the same time. For certain crossing it will be necessary to emasculate all the flowers of one parent arrow. Even if we succeed in cutting off the majority of the flowers without injuring the rest, each experiment would mean the erection of a lofty staging with practically a glasshouse at the top in which an assistant could use a dissecting microscope. The state of the weather would usually render futile any less cumbersome arrangement. This is at present out of the question. Certain, direct crossing does not at present appear to be feasible at Coimbatore and, added to this, the outlook for such work is discouraging because the results obtained at Barbados appear to have been unsatisfactory, one after another of the carefully nurtured crosses having been abandoned on being tested in the field.

There are two ways which suggest themselves of approaching the problem of obtaining known crosses indirectly. It has been noted that the different cultivated varieties of sugarcane vary a great deal in the development of their essential organs. Some have never been observed to flower: others have flowers which do not emerge from the enveloping sheaths: yet others have partial or total sterility in male (or female?) organs, while a number produce healthy arrows with good pollen and fertile ovules. The commonest case at Coimbatore is that only a certain percentage of stamens open. If we could obtain a variety in which no pollen is formed at all or no stamens open (and there seems to be a close relation between the two, stamens which do not open not containing fully formed pollen and the converse), crossing that variety with one producing good pollen would be easy. One or two such cases have already been observed and crosses obtained, but these happen to be of little value from the economic point of view. The best local cane at Coimbatore, the 'Vellai,' arrows freely every year but produces comparatively little good pollen. Advantage has been taken of this during the past year to pollinate this variety with about a dozen others, in the hope of obtaining crosses between them. The withered flowers of each arrow are kept and carefully analysed as to the percentage of open anthers, and the probability of obtaining crosses or selfed seedlings is calculated therefrom. But, unfortunately, some open anthers are always noted (often about 2 %) in Vellai, and we shall have to depend on further study of the seedlings before we can definitely say whether we have been successful.

A second way of approaching the problem indirectly is opened for us by the fact, now observed for two years, that certain varieties produce

many seedlings, when selfed, which, however, die off at a very early stage. In one case 13 survived out of 4000 in the first year, and a hundred or two out of 10,000 in the second. This would appear to be a varietal character, and two other kinds appear to share this peculiarity. It is, therefore, proposed to pollinate these three, if possible, from other good kinds during the next season on the chance of obtaining a more vigorous lot of seedlings. If we succeed in raising thereby a large number of vigorous seedlings, it may be safely assumed that the bulk of them will be crosses.

Problem 5. It has been suggested that it may be possible to decide the parentage of seedlings by observing their subsequent habit and growth, but we shall require for this purpose a very complete knowledge of the morphological differences of the parents. The problem of classifying the canes thus acquires additional importance. Considerable progress has been made in this direction during the past year and a half. A remarkable number of minute distinguishing characters have been recorded in examining the different canes collected, although this work is still far from complete. A few of these characters may be mentioned here and those interested in the subject are referred to a paper on "The Panjab Canes" about to be published as a Memoir of the Indian Agricultural Department. In this paper a summary of the chief characters studied up to date is given, in order to explain the descriptions of the canes figured.

The habit of the cane as it strikes the eye appears to be extremely important and characteristic. Its erectness, tillering power, shooting of buds, rooting at aerial nodes, leaf angle and leaf endings, as well as liability to be attacked by certain fungi, form useful determining characters. The joint (made up of a node and the internode above it) varies in thickness, length, shape, number, growth curve (the relative length and thickness in different parts), ovalness, hardness of rind, quantity of fibre, juiciness, richness and other properties of the juice, colour, waxy bloom and relative development of leaf scar, circlet of hairs, root zone, growth ring, bloom band, etc., in different varieties. The bud presents important details as to shape, size, mode of bursting, flanges (lateral expansions of basal scales), vestiture in bristles, basal patches of hairs and minute black hairs. The lamina, leaf-sheath and ligule all show similar acts of diagnostic characters, in which various types of hairs play an important part, the leaf-sheath especially presenting a surprising number of differences. As a result of this minute morphological examination of the canes, there appears to be some

prospect of arranging the Indian canes into a series of alliances, although it is not always possible to determine whether similar canes from

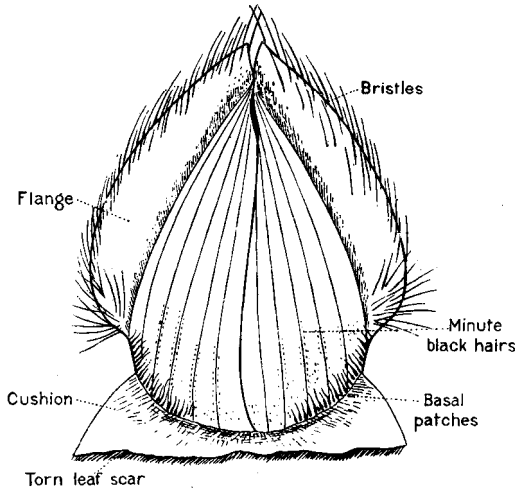


Fig. 8.

different localities are permanently separable or merely local varieties induced by their special surroundings. A natural system of classification is being attempted in which the members of the different groups

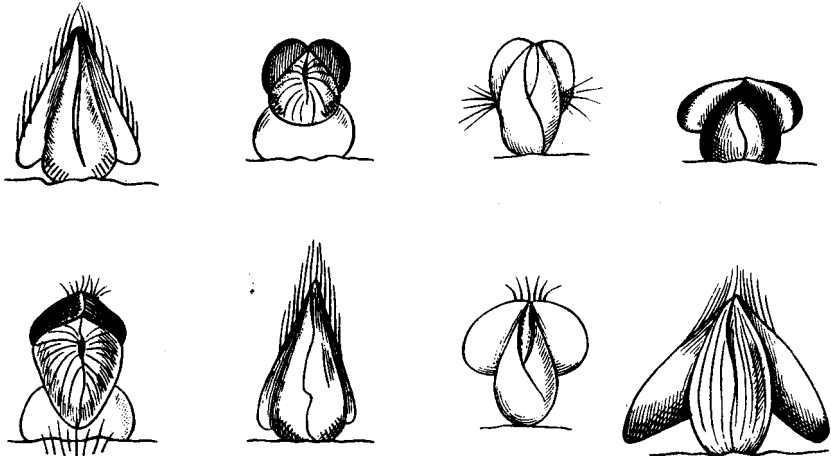


Fig. 9.

resemble one another in as many as possible of the characters referred to above. In such a system agricultural, botanical and chemical characters will all have a place.

Problem 6. The question now naturally arises, are these characters

constant in different localities and under diverse conditions? What stability is to be expected in such minute vegetative separating marks and what are the limits of variability, especially in quantitative characters? There is no doubt that the sugarcane responds very readily to change of habitat. This fact will increase the scope of the detailed study described in the last section, in that the same varieties must be studied for several successive seasons both in North India and at Coimbatore. We already know of characters which are unstable in certain varieties under changed conditions, although they appear to vary less in others. The ivory markings in the joint are usually a good character, but in some kinds of cane they are readily affected by changes in climate (moisture?). The colour of the cane has been observed to change in some varieties in transfer. Canes which appear to be immune to fungus attacks in one district are at once attacked and destroyed by the same species of fungus in another. There are a number of other characters which have been noted as varying in this way, and it is possible that, while firmly fixed in certain kinds of cane, they are variable in others. These facts will naturally increase our difficulties when we attempt to trace the characters of any parent in a seedling by observing its morphological characters. But, in consideration of the facts noted in the next paragraph, it will be seen that these difficulties are greatly increased.

Problem 7. Of what value are the characters noted above in separating seedling canes? Are any of the minute differences observed in varieties propagated vegetatively handed down unaltered in seedlings derived from them? At present there is not sufficient material available to answer these questions. But one of the most obvious features in any batch of seedling canes from a common parentage is the extraordinary amount of variation among them. And this is especially noticeable in those characters of habit which appear to be so stable and valuable in varieties in the field. The seedlings appear to differ in every direction—habit, joint, colour, leaf, juice, etc. We have already collected a certain amount of material for the detailed study of this question. Last year we obtained 70–80 seedlings from Strakarchynia (a thin Behar cane) fertilised by *Saccharum spontaneum*; 13 from Chin (a thin U.P. cane) also fertilised by *Saccharum spontaneum*, and 71 selfed seedlings of Saretha (a thicker cane of the U.P.). As far as time has permitted, a detailed study has been made of these seedlings and the descriptions of them recorded, and it is hoped that, when these descriptions are analysed, some useful facts may be obtained. One difficulty is encountered, however, in our inability to apply the



Fig. 2. A cane field in Madras.



Fig. 3. A cane field in Behar.



Fig. 4. A canefield in the Panjab.



Fig. 5. Cane seedlings at Coimbatore.

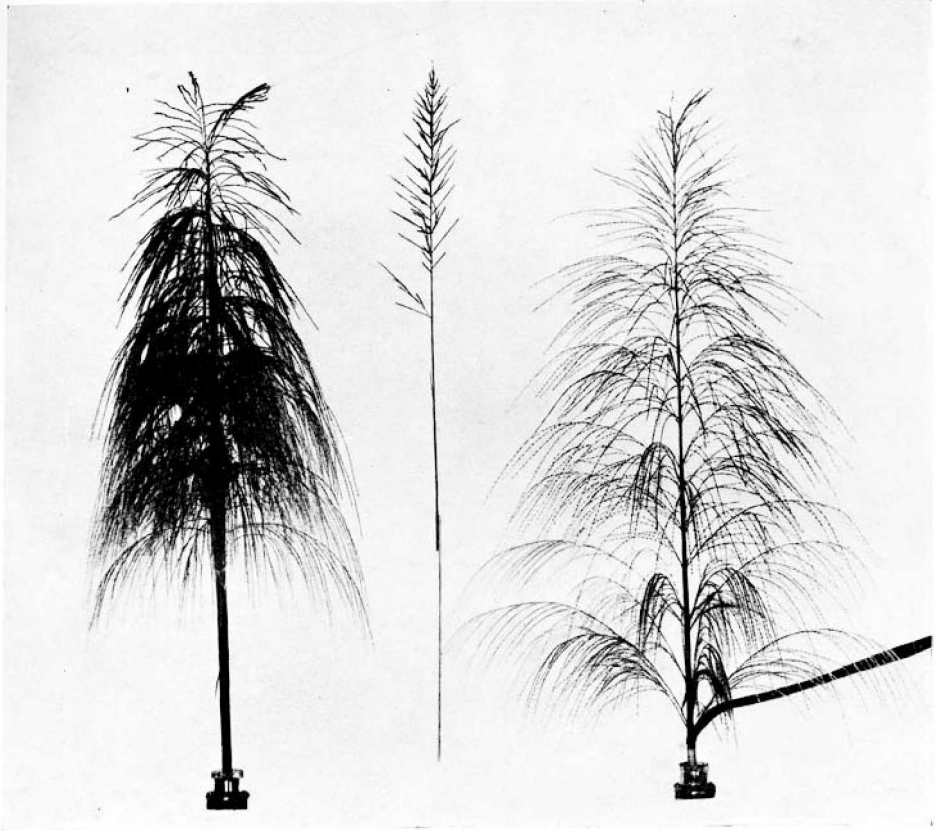


Fig. 6. Cane arrows, left Vellai, right Ashy Mauritius, middle *Saccharum narenga*.

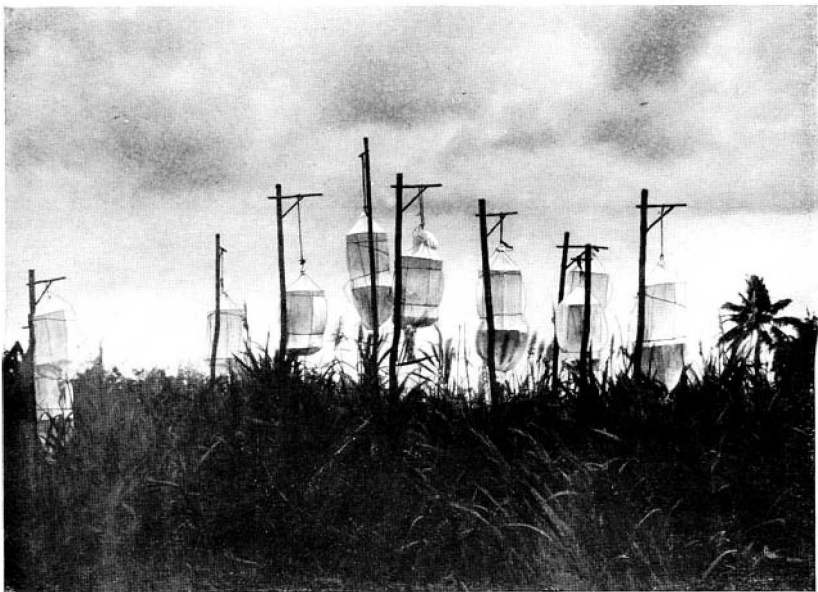


Fig. 7. Arrows protected from casual pollination.



Fig. 10. Saretha cane in the field.



Fig. 11. Selfed seedlings of Saretha cane.

stereotyped description of cultivated canes (*Saccharum officinarum*) to the wild *Saccharum spontaneum*, for this species is regularly propagated by seed all over India, and the seedlings appear to vary so much among themselves in certain characters that individuals may be placed in almost all the groups already marked out among the cultivated forms. This, however, is a fact not without its significance in our efforts to trace these cultivated forms from *Saccharum spontaneum* itself.

The attempt to determine the parentage of seedlings by their morphological characters of their vegetative parts is thus beset with difficulties, and these are not decreased by the possibility of many characters being intermediate or recessive in the offspring.

Taking these uncertainties into consideration—and there are, naturally, many chemical and agricultural ones not yet fully grasped—the main line of work in the cane-breeding station for the present lies in the direction of selecting suitable parents, preserving the healthy offspring of the best of these, analysing the juice after the first year's growth and observing the relative vigour of growth and choosing the best for further observation—a narrowing circle in which ultimately a few of the best all-round will remain to be sent to the chain of agricultural stations in the north for a renewed series of tests there before dissemination among the cultivators. In all cases it will be our aim to cross good North Indian canes with good South Indian or Exotics, and in the case of the former the importance is recognised of choosing one parent which is largely grown and valued in the particular part of India to which it is intended to send the resulting seedling for trial.

EXPLANATION OF FIGURES.

- Fig. 1. Map of India indicating roughly the northern and southern tracts over which sugarcane is grown. The acreage under cane is ten times as great in the northern region as in the southern.
- Fig. 2. A modern canefield in Madras.
- Fig. 3. A good canefield in Behar.
- Fig. 4. A good canefield in the Panjab.
- Fig. 5. Cane seedlings at the Cane-breeding Station at Coimbatore.
- Fig. 6. Cane arrows, in left of Vellai, in right of Ashy Mauritius. In the middle, the arrow of *Saccharum narenga*.
- Fig. 7. Arrows protected from casual pollination (at a village ten miles from the cane-breeding station).
- Fig. 8. A typical sugarcane bud.
- Fig. 9. Various forms of sugarcane buds.
- Fig. 10. Saretha cane in the field—a moderately thick North Indian variety—with very characteristic, erect and ascending shoots.
- Fig. 11. Selfed seedlings of Saretha cane. These vary from strict, erect to absolutely prostrate seedlings. The latter are seen in the foreground (left) and the prostrate habit is fixed in all descendants produced vegetatively from them.