

SOME ASPECTS OF SUGAR CANE BREEDING IN MAURITIUS

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Arrowing of Sugarcane.

The first arrows of the season generally protrude during the second fortnight in May. Crossing is in full swing in June and July, but a few crosses are made in August to supplement those made in the previous months whenever there has been a shortage of arrows.

The breeding plots comprise a fairly wide range of male and female parent varieties, as a rule prolific, and a large number of crosses is made to provide a sufficiency of seedlings for the first-year trials. The crossing programme can usually be carried out as contemplated.

Parent varieties are classified in three categories: (a) males, (b) females, (c) intermediate types. Varieties of the (c) group have arrows containing flowers producing pollen and flowers with yellow anthers bearing sterile pollen grains. Parent varieties of the intermediate type are generally used as males, but they are also used as females in differential crosses when, on being selfed, they produce no seedlings or very few seedlings.

Certain varieties have been found to vary in their degree of male fertility in the course of the arrowing season as well as from year to year. The amount of pollen shed by certain male parent varieties varies with altitude. In M.63/39, for example, the percentage of red anthers and quantity of pollen produced decrease from the low-lying to the more elevated regions of the Island and, as a consequence, this variety is a strong male at Pamplemousses, a male of medium fertility at Reduit, but gives rise to little pollen at Hermitage.

The real test of the actual fertility of male and female parent varieties is their prolificacy on being crossed. The number of seedlings obtained per cross varies from zero to several thousands, depending on sexual compatibility.

No attempt is made at preserving the pollen of early flowering varieties for pollinating late female varieties. Investigations have, however, been carried out to store pollen in a viable condition for export to South Africa for crossing purposes. Uba Marot pollen, for instance, could be kept fertile for a period of ten days by storing it at low temperatures in a refrigerator. A special apparatus has been sent to Mauritius by the Mount Edgecombe Experiment Station for the purpose of despatching pollen to

South Africa. The first consignment of pollen was sent by air freight last year, but the experiment was a complete failure due to the journey having been too long.

All attempts to induce arrowing in non-arrowing varieties such as R.P.8 and B.H.10/12 have so far proved unsuccessful. Methods to induce arrowing have comprised: (a) photoperiodism, (b) geotropic stimulation, (c) control of growth conditions by high phosphate dressings, (d) planting under water-logged conditions, and (e) stem and leaf injection with juice obtained from cane bearing rudimentary inflorescences. Two B.H.10/12 arrows have been obtained in a plot to which phosphatic guano had been applied at the rate of 800 kgs. per acre, and the experiment is being repeated to determine whether this particular treatment has a definite effect on flower initiation in B.H.10/12.

The technique to be adopted in 1952 to try to induce flowering in the two above-mentioned varieties will be radically changed. It is based on the fact that the tendency to vegetative and reproductive developments is controlled not by the presence or absence of any flower-forming hormone, but by the concentration of auxin in the plant. Experiments will be carried out with auxin-antagonistic compounds.

Choice of Parent Type and Blood Lines.

Before the inception of the Sugarcane Research Station, sugarcane breeding consisted chiefly in raising seedlings from seed collected from wind-pollinated arrows. The adoption of crossing methods constitutes one of the most notable advances in the breeding work. In the formulation of any constructive breeding scheme, it is very important that the parentage of every seedling should be known. Although accurate knowledge of the inheritance of individual characters in sugarcane is still lacking, cane breeding is not a hit-and-miss affair as it was in the past. The choice of parental varieties and the discovery of adequate crossing methods have largely contributed in removing the element of empiricism characterising the old methods. Up to the present, it can be said that the production of superior commercial varieties depends more on the finding of suitable parents by practical breeding than on theoretical considerations.

Progeny tests to assess the potentialities of parent varieties have been made on a certain scale in Mauritius, and they were, for a time, included in the breeding work as a routine measure. It is admitted that progeny testing is one of the most suitable methods at the breeder's disposal for evaluating crosses. The method used, which consisted in planting at random about 100 seedlings from each of several crosses in one experiment, labours under a serious disadvantage: interaction between the seedlings damps the free expression of the phenotype and thereby partly invalidates the conclusions regarding the relative value of crosses and parental types.

Progeny testing has now been resumed, but the method of layout is different from what it was before. The seedlings from the various matings are arranged at random in the rows in groups of five to ten per cross, and there are 20 replications.

In the early years of the Station's activities, crosses between noble canes were made on a comparatively large scale, but they have now been largely superseded by crosses involving wild blood which yield more variable progeny.

A criterion of the value of parent types is the range of variation displayed by their hybrid seedling populations. It is better to concentrate on crosses producing the greatest extremes of variation in their seedlings; such crosses are preferred to those giving a higher proportion of good, but not outstandingly good, seedlings.

It was realised that the introduction of wild blood would be necessary to bring about resistance to pests and diseases in the hybrid seedlings. Early work indicated that varieties of the fourth-nobilised *Saccharum spontaneum* type were most likely to prove suitable to local conditions, and the results of many years' experience have substantially confirmed this expectation.

P.O.J.2878 has proved to be an outstanding female parent variety in this Island. In combination with D.109 it has produced M.134/32, an outstanding variety now contributing to over 95 per cent. of the cane lands. P.O.J.2878 is, unfortunately, not prolific when crossed with noble canes, and crosses have to be replicated for the production of reasonably large hybrid populations. There are indications that this variety is also capable of handing over its high sucrose content to its progeny when used as a male parent; in combination with R.P.8 it has yielded M.112/34, one of the richest seedling cane varieties ever produced in Mauritius.

Another interesting line is that involving Uba Marot blood. This most vigorous cane was discovered by L. Marot, a planter in the Black River district, in 1923. It occurred as a rogue in an old ratoon field

of the noble cane 131 P. bred by Perromat. Cytological investigations carried out by G. C. Stephenson show that it is, in all probability, a first-nobilised *Saccharum spontaneum* cane derived from a natural cross between 131 P. and a form of *S. spontaneum* occurring wild in Mauritius. In one way, therefore, the case of Uba Marot is interesting as it offers a striking similarity to that of Kassoer in Java: the pedigree of both varieties remains empirical.

In 1934 Uba Marot was crossed with M.109/26, a noble cane, and produced a hybrid seedling of extraordinary weight: 190 kilos. This seedling, numbered M.99/34, has been extensively used as a male parent for crossing with several female varieties, notably M.134/32 and M.112/34, with a view to breeding complex hybrids. The derivatives of crosses between M.134/32 and M.99/34 are extremely vigorous, but are generally of lower sugar content.

An outstanding seedling bred from Uba Marot is Ebene 1/37, obtained by O. d'Hotman de Villiers at Highlands Estate. This variety has been obtained from crosses involving P.O.J.2878, Uba Marot and two noble canes, R.P.8 and M.27/16. It is very rich and crops particularly well in the wetter localities of Mauritius. Since the sucrose content of R.P.8 and M.27/16 is low and that of Uba Marot very low, it must be concluded that the good juice qualities of Ebene 1/37 have been handed over from P.O.J.2878.

A step forward in the production of vigorous and rich agrotypes lies in crossing the derivatives of crosses between M.134/32 and M.99/34 with richer parent types. Back-crossing with one of the ancestors, namely, P.O.J.2878, is also being effected, and it is hoped that the work of breeding high sucrose yielders will be brought to fruition in a reasonably short time.

Breeding Policy.

When the Sugarcane Research Station was founded in 1930, the old varieties which had been the backbone of the industry for several decades were deteriorating and required immediate replacement. Special types of canes were required: (1) drought-resisting varieties for the dry localities of the north of the Island, (2) varieties capable of resisting root destruction by the larvæ of *Clemora Smithi*, and (3) canes suited to the leached soils of the uplands regions.

Some of these objectives have already been achieved by the production of M.134/32. But there still remains the problem of this variety deteriorating in the future—although it is probably a good way from the end of its era of commercial popularity—so that continuous efforts are necessary to breed a substitute for it.

The present breeding policy is dominated by the need for producing heavy yielders of high sucrose content for the cool and superhumid areas where the soil has become very poor through the continuous leaching action of rainfall. These areas, totalling some 20,000 acres, are to be found mainly in the central and south-eastern districts of the Colony. Experiments are in progress to rejuvenate these soils by the addition of basalt dust, but there is no doubt that the best way of making these soils more productive is bound up with the production of suitable varieties. As previously mentioned, the variety Ebene 1/37 appears particularly well suited to the soils of these regions and should constitute an admirable stop gap until the Sugarcane Research Station finds a seedling of its own raising.

Now that the sugar crop is distributed over a longer period because of the heavy tonnage, the Station is also concentrating on raising early maturing varieties capable of having satisfactory juice early in the season.

Crossing Technique.

The bulk of the crosses is made in the standard single-arrow lantern. These lanterns are of simple design and can be set up on one bamboo pole. They are placed on the female arrows in the field when the first flowers begin to open. One or two male arrows standing in 0.03 per cent. SO_2 solution contained in a bamboo pot are placed over the female arrow. The male arrows are cut with several feet of stalk and are renewed at varying intervals, depending on their longevity in SO_2 solution. The preserving solution is renewed and a node of the stalk cut every other day.

Investigations have been carried out on the isolation and preservation of female arrows in a solution containing SO_2 and phosphoric acid at the usual concentrations. The results have been erratic, and the method is not considered practical under local conditions.

Field Planting of Seedlings.

Seedlings are transplanted when 20-30 cms. high. No attempt is made at selecting the most vigorous ones, but the weaklings are retained in the nursery and used for filling blanks later should any occur after planting.

Spacing trials have shown that a satisfactory distance is 3 to 3½ feet in the row. Wider spacings might be better from the point of view of reducing competition in the seedling populations, but would be too extravagant of space.

The number of seedlings planted in the field varies somewhat from year to year, but is usually about

20,000. The number planted per cross depends on the prolificity and value of that cross. As the crossing programme sometimes involves many experimental crosses, a large number of families has to be tested in the field for determining their potentiality.

The question of whether it is more desirable to plant fewer seedlings from many crosses than a larger number from fewer crosses is a moot point. Owing to the heterozygous nature of sugarcane, random populations of seedlings generally exhibit a wide range of variation. Planting a large number of seedlings from a very promising cross should, therefore, increase the odds of coming across outstanding combinations of commercial qualities.

The planting of sprouted single-eyed cuttings of a standard variety in the central and marginal rows of the seedling plots has been a routine practice for quite a long time. The planting of these setts in pots in the nursery is so adjusted that the young shoots are of approximately the same height as the seedlings when ready for transplanting.

As far as local experience goes, inter-planting a clonal variety with the hybrid seedlings does not allow of comparisons being made between the weight of the seedlings and that of the clonal stools, and the method is of no value for the study of the inheritance of yield in seedlings. From the point of view of assessing the value of parent varieties as producers of rich seedlings, the method is valuable.

Present Methods of Seedling Selection.

The selection of the best seedlings from the hybrid populations is beset with difficulties. Selection patterns vary with different countries but, as a rule, the aims in view converge on producing specified cane varieties suited to particular sets of environmental conditions. The difficulties inherent in the selection work are due mainly to soil variations and to the fact that each seedling occurs once only, and that its yield, therefore, is subject to a certain experimental error. The breeder must be able to differentiate between a genetic variation and environmental variation. The hybrid populations constitute an unbroken continuum for possibly every individual character, and large populations are necessary so that as much as possible of the range of variation shall be represented.

Variation due to extrinsic factors can be studied in clonal populations derived vegetatively from setts. In such populations, the genotype is fixed and, therefore, stool-to-stool variation due to the interplay of environmental factors. A co-efficient of variability of as high as 50 per cent. was found by Evans for the variety R.P.6 growing in a uniform field; the mean stool weight was 16 kilos and the

standard deviation of the order of 8 kilos. This high clonal variation is bound to have a bearing on seedling selection, especially in view of the fact that each seedling is unreplicated.

In the light of the above considerations, it appears that little significance can be attached to differences in seedling weights, even if the populations are confined to a restricted area. At the present, little emphasis is laid on the stool yield and selection standards are such that a higher proportion of seedlings is selected for further trials.

Selection is based mainly on appearance, brix of juice, absence of diseases, low percentage of arrows, etc. Juice samples for reading the brix are taken with a juice sampler (Gempol knife) at the middle of the stalks; two composite samples from five canes each being taken per seedling.

The factual basis of the tests for "total solids" is the linear relationship found between the percentage of total solids in the juice and sucrose per cent. cane.

A large number of seedlings can be examined with the hand refractometer, and their brix is compared with that of the clonal variety whose stools are distributed regularly throughout the seedling populations. The brix of any one selected seedling is compared with that of the nearest stool of the control variety. There is sometimes much variation in the brix of the clonal variety itself and, therefore, seedlings with a lower brix than that of the control are selected, provided that they have no objectionable characteristics which may be a bar to their ever becoming commercial canes. Such seedlings can be rejected from propagation plots or second trials should they prove to be of low sucrose content. Moreover, the low correlation coefficients found between the brix of seedlings in first and second trials suggest that not much reliance should be placed on brix figures.

It is unnecessary to lay stress on the other aspects of the selection work. The only point worth while discussion in some detail, however, is the selection of seedlings from first ratoon populations. The necessity of selecting seedlings in ratoon is based on the fact that ratooning qualities are of vital importance in a country like Mauritius, where the cultivation of sugarcane up to the sixth ratoon crop is a common practice.

The results of research work carried out on seedling selection from first-ratoon populations are summarised hereunder.

1. It is imperative that seedlings possessing sound ratooning power be selected at an early stage of the breeding work. When selecting seedlings from plant cane, doubt exists in the breeder's mind regarding the ratooning capacity of his selections. However, it

must not be contended that because a seedling gives a high weight in the first ratoon, that it will prove a sound ratooner, but the odds are in favour of it.

A correlation coefficient of +0.5 was found between stool weight as exhibited in virgin and ratoon, suggesting that there is far from existing a one-to-one correspondence between the yields of the two successive crops. It must, however, be borne in mind that correlation has statistical value and may break down when the performance of individual seedlings is considered.

2. The number of seedlings selected in virgin and ratoon for further testing in second trials is, in the aggregate, more than double the number selected in virgin only. When ground space is available for testing a large number of selected seedlings, selection can be made from the virgin and ratoon populations. Selecting a high percentage of seedlings for planting in propagation plots or direct in second trials, increases the chances of finding a superior variety should there be one in the seedling populations, and decreases the probability of some particularly good variety being selected without trial.

3. Selection is easier in the ratoon stage due to the better growth habit of the seedlings. In the case of long season virgins, lodging renders selection difficult. Ratoon seedlings being, as a rule, shorter and more erect than plant seedlings, there is less competition for growth in the ratoon populations and selection for stool weight is made reliable. Even with wider spacings it is difficult, if not impossible, to eliminate border effect completely.

4. Ratoon canes are generally less liable to be damaged by cyclonic winds than virgin canes. This is a factor of importance in an island like Mauritius where tropical cyclones are of frequent occurrence.

5. It is, as a rule, easier to eliminate heavy arrowers in ratoon. Seedlings very often do not flower in virgin if the growth period has been short.

Mr. Brett thanked Mr. de Sornay for a most interesting paper. Referring to intermediate males, he said that varieties which produced a certain amount of pollen in the field could usually be converted into useful males in the glasshouse. He said that from some efforts we had got quite a number of selfs, and some of these seemed fairly vigorous. He stated that low night temperatures resulted in little pollen being formed, and suggested that the lower pollen fertility of some varieties at higher altitudes in Mauritius might be due to this reason. We did use the starch test for testing the results in the glasshouse, but dehiscence of anthers was the criterion used for estimating the probable value of tassels for use as male

parents in crossing. Mr. Brett said that crosses in the field did not seem to be as successful as those in the glasshouse. He said he had tried using Aretan instead of sulphurous acid, but had not found it by any means as effective.

Mr. de Sornay suggested that the concentration might have been too high.

Mr. Brett said that usually he had no trouble about renewing male arrows as these seldom died prematurely. He said that here wider spacing of seedlings was used than in Mauritius. They were spaced 4 feet apart in the rows, instead of $2\frac{1}{2}$ feet, and a line was left out between each double row.

Mr. de Sornay said that they did not do that in Mauritius.

Mr. Brett said he had tried the brix test, but found they discarded very few seedlings on the brix.

Mr. de Sornay replied that if they relied on weight they would never discard any stools, so that they had to rely on the brix.

Dr. McMartin complimented Mr. de Sornay on the amount of information in his paper. He said that it

was obvious that in Natal we had a lot of experience to gain in cane breeding. He said that obviously a most important factor in producing commercial canes was having the right parent canes. He felt that there was a great deal in what Mr. de Sornay said that would be a direct benefit to us here. He asked Mr. de Sornay what the policy was in the selection of parent canes—those that gave a uniform lot of seedlings or those that gave great variation.

Mr. de Sornay said that they preferred extremes rather than uniform populations.

Dr. McMartin asked if there was anything to be gained in selecting at as early a stage as possible, and if there was anything to be gained by trying to take short cuts in the selection methods.

Mr. de Sornay said that they did not try to select at too early a stage.

Dr. McMartin said that if we selected only on ratoons it would take too long as here we had a two-year crop. It had been tried, but had not been found to have any particular advantage. Our selection procedure in the past had been rather to eliminate the worst at any early stage, rather than try to select the best.