

THE FIRST TEN YEARS OF SUGARCANE BREEDING IN NATAL

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The conclusion of the tenth successive crossing season seems an opportune time to review the present status of sugarcane breeding in Natal. In doing so, the methods of the present will be considered in relation to the results of the past and the aims of the future. The opportunity will also be taken of considering possible changes in the present variety position.

Sugarcane Breeding in Natal from 1944 to 1953

Since the first seedlings of commercial types of sugarcane were raised in 1944, steady progress has been made in extending the scope of sugarcane breeding in Natal. The first seedlings were obtained by collecting and sowing the seed of tassels which had matured naturally in the field.¹ Only thirty-six seedlings were obtained in this way, but nevertheless the fact was established that the sterility of sugarcane under Natal conditions was not complete. The seed collected from the field almost certainly resulted from self-fertilization. Hybridizations were successfully carried out for the first time in 1945. Unfortunately only a few of these hybrids came from crosses between commercial types of cane—most were from crosses in which the pollen parent was a *Saccharum spontaneum*, or "wild," form of sugarcane. The major obstacle to sugarcane breeding in Natal—pollen sterility in commercial types of sugarcane—had still to be overcome.

In 1946 some success was obtained in inducing the variety Co.301 to produce fertile pollen. This was done by subjecting flowering shoots to artificial conditions which included night temperatures higher than the normal. However, several years were required for the development of a really satisfactory technique for increasing pollen fertility,^{2 3 4} and it was not until 1949 that reasonably large numbers of seedlings were being raised. Since then, improvements in technique and increasing experience have further extended the scope of sugarcane breeding in Natal. Recent findings have enabled the female fertility of many varieties to be increased by the use of the technique devised originally for increasing male fertility⁵ and have also made possible the improved preservation of detached shoots used in pollen fertility studies. This better preservation results from the stimulation of rooting which follows the addition of methoxy ethyl mercuric chloride—at the rate of 4.5 parts per million—to the standard sulphurous acid-phosphoric acid preserving solution.

Though the annual production of seedlings has tended to increase fairly rapidly, the advance has not

been altogether a steady one and fairly wide fluctuations have occurred from year to year. These fluctuations have for the most part been brought about by variations in the intensity of tasselling. A fairly good indication of the trend in seedling raising from 1944 to 1953 is given by the three-yearly averages presented below—in each case the year given is the central one of its period.

Year	No. of Seedlings planted in the field (3-yearly averages)
1945	430
1946	436
1947	1,201
1948	5,418
1949	9,113
1950	10,885
1951	14,919
1952	21,936

By 1953 the number of seedlings planted individually in the field had reached 32,192; in addition, during this year about thirty thousand seedlings were planted in bunches.

Present Policy and Methods in Sugarcane Breeding

The aims of sugarcane breeders are the same throughout the world—the production of varieties yielding the maximum returns under the conditions for which they are intended—but different means are used in different places to attain the same end. The work of sugarcane breeding can be divided into two separate and distinct processes—the development from seed of new and superior varieties, and the separation of these superior varieties from the inferior ones which inevitably accompany them. Many variations of technique have been evolved in different parts of the world for handling these two processes.

The Production of Superior Types

The sugarcane breeding policies of most countries are based upon the use of trial crosses and are fundamentally similar. Usually a large number of trial crosses are made, and a relatively few seedlings of each planted in the field; the crosses found in this way to be the most promising are then repeated on as large a scale as possible. In Hawaii this system of breeding has been replaced to a great extent by one based upon the so-called "melting-pot" technique. Economic reasons have been largely responsible for

this change, melting-pot crosses being easier to handle than controlled crosses. Only the female parent is known of a seedling from a melting-pot cross, however, and if an outstanding seedling is obtained, the cross which produced it cannot be repeated. Obviously trial crosses cannot be used with this technique.

For the most part the making of controlled crosses presents fewer difficulties in Natal than in other countries. The advantage sugarcane breeding in Natal enjoys in this respect arises from what was once considered its greatest disadvantage—complete pollen sterility of most tassels under field conditions. This pollen sterility makes possible the extensive use of area crosses—these, though controlled, require less supervision than the usual bi-parental crosses. In making these crosses, tassels of one male variety, previously kept under controlled conditions to increase its pollen fertility, are used to fertilize the tassels of any number of female varieties taken from the field. In tropical countries it often happens that tassels which are not completely pollen-sterile have to be used as females. In such cases, if controlled crosses are to be made, only two varieties can be crossed at the same time—and even so, some self-fertilization may occur.

The making of area crosses in Natal is likely to be complicated by the development of the technique—mentioned above—for increasing female fertility. With this technique, pollen fertility is likely to be increased as well as ovule fertility. It is hoped a careful control of the temperatures to which the developing inflorescences are exposed, or of the duration of the treatments, may enable ovule fertility to be stimulated without at the same time affecting pollen fertility. If no such method of control is found, some deviation from the present policy of making controlled crosses only may prove advisable.

The use of trial crosses as a breeding technique has sometimes been criticised on the basis that a few hundred seedlings are unlikely to provide a proper indication of the full potentialities of a cross, especially as it is the exceptional, rather than the average seedling of a cross, that determines its value. This disadvantage is probably not in itself sufficient cause for abandoning the whole technique. It would seem reasonable to infer that a cross having a high average performance for its seedlings is more likely to produce seedlings of commercial standard than one having a low average performance—a correlation, not an absolute agreement, is to be expected between the averages and the extremes of crosses. In addition, in estimating the value of a trial cross the average performance of its seedlings need not provide the sole criterion—a few fairly promising types amongst a great many inferior ones can indicate that the cross might have valuable potentialities, and be worth repeating.

For the reasons given above, it is intended to continue with the system of controlled pollinations and trial crosses as at present used in Natal. A record is being kept of the estimated value of the different crosses at the single stool stage; this estimated value is recorded by the appropriate number on an arbitrary scale ranging from 0 to 6. At a later stage, a comparison of the estimated values of the various crosses and their actual values as shown by the performances of their seedlings should provide a useful check on the soundness of the technique at present in use.

It often happens that only one of several possible crosses can be made, and certain generalisations may then be of help in deciding which cross should be attempted. For this reason records are kept for each variety of all the crosses in which it is used. The usefulness of these records in evaluating the breeding behaviour of varieties should increase with time. In the meantime it is necessary to avoid preconceived notions likely to restrict the range of crossing; at present the best rule would seem to be that trying everything once—in so far as this is possible.

Seedling Selection

The Criteria of Selection

The process of selection aims at a progressive elimination of less desirable seedlings until eventually only seedlings of commercial standard remain. The majority of seedlings are discarded because they lack vigour: obviously stunted seedlings are soon discarded; variety trials are necessary for eliminating the seedlings whose yields in sucrose per acre fall only slightly below those of standard varieties.

The next most frequent cause for eliminating seedlings is disease susceptibility.

Seedlings at the first stage of selection that are found infected with the virus diseases of streak, mosaic, or chlorotic streak or with the fungus diseases of smut or red rot, are always discarded. Characteristics regarded as undesirable, but if not pronounced, as insufficient cause in themselves for discarding seedlings, include the following:

- (1) thinness, pithiness or hollowness of stalks;
- (2) lodging or other type of inferior habit;
- (3) susceptibility to minor diseases;
- (4) the presence of dead stalks in the seedling stools;
- (5) sprouting of buds on growing canes;
- (6) clinging of trash;
- (7) hairiness of leaf sheaths;
- (8) tasselling, especially during the first season's growth.

The criteria used in the selection of seedlings must necessarily alter with time. With changing agricultural conditions, characteristics formerly considered desirable may become of minor importance—or a directly contrary effect may be produced. In this way the development of mechanical harvesting in Natal might place a premium upon the possession of an erect type of habit, but decrease the importance of a reasonably smooth leaf-sheath.

Methods of Selection

In order to take full advantage of the increased number of seedlings that can now be raised in Natal, it will be necessary to alter the present technique of selection. This technique for the most part was devised for handling the relatively small numbers of seedlings that were raised from introduced seed. A reorganisation of existing facilities should enable many more seedlings to be tested; but for the fullest advantage to be taken of the greatly increased scope of sugarcane breeding that recent developments have made possible, two additional facilities are required. In the first place, regional stations are needed so that seedlings can be tested at an early stage for this adaptation to the main agro-ecological regions of the cane belt. In the second place, a limited amount of irrigation is needed to facilitate the transplanting of seedlings to the field. By making the time of transplanting independent of natural rainfall, irrigation would also permit proper planning and enable the best use to be made of the available land.

The proposed changes, which it is hoped will enable more efficient use to be made of the resources at present available, are tabulated below:

*Methods at Present in Use, or
in Use until Recently*

Proposed Changes

1. Seed Sowing

Seed sown immediately available, i.e. from July onwards. (Usually transplanting of seedlings to the field is not completed until the following January.)

Seed to be sown in February or March, being stored until then in a deep freeze at 0°F. (Seedlings should be ready for transplanting to the field at the best time of the year, i.e. after the first spring rains.)

2. Surplus Seedlings

When more seedlings were raised than could be planted individually in the field, some of the seedlings of different crosses had to be discarded without trial.

Proposed changes in the methods of selection should increase the number of seedlings that can be handled on the available land. If a surplus is obtained, however, testing for mosaic resistance should enable some of the seedlings to be discarded while still in their pots. The method of bunch-planting developed in Hawaii affords a way of handling seedlings that would otherwise have to be discarded as surplus.

3. Seedling Pots

Single 6-inch pots of the usual conical shape.

Straight sided, compound pots, 12" × 8" × 4", each holding 6 seedlings. These pots have no bottoms, and have to be stood on concrete.

4. Time of Hardening Seedlings

Seedlings not moved out of the glasshouse until a week after transplanting to pots.

Seedling flats moved outside the glasshouse a week or two before the seedlings are due to be transplanted.

5. Stages of Selection

First Selection

Single stool seedlings spaced 4 feet apart in rows alternately 4½ and 9 feet apart. Selected on appearance about 2 years after transplanting to the field.

First Selection

Single stool seedlings spaced 2 feet apart in rows 4½ feet apart. Selected on appearance about 1 year after transplanting to the field.

Second Selection

Seedlings allotted 6-foot portions of lines which are spaced alternately 4½ and 9 feet apart (only 3 feet planted with cane, remaining 3 feet left blank). Selected after 2 years on the basis of general appearance and brix tests with a hand refractometer.

Second Selection

Seedlings planted into lines 25 to 30 feet long. Harvested after 2 years. Final selections made from the appearance of the first year ratoons and the weights and sucrose tests of the plant cane crop.

Third Selection

Seedlings planted into lines 40 to 50 feet long. Half of each line cut at a year old. Final selections made on weights and sucrose tests of 2-year-old cane and on appearance of first year ratoons; the ratoons used as source of seed material.

Fourth Selection

Single plot trials, arranged so that each seedling is adjacent to a control variety. Weighed and sucrose tested when 2 years old.

Third Selection

Replicated plot trials.

Fifth Selection

As shown in the above table, the proposed changes in technique would add two more stages to the process of selection, but only two more years to the time needed for obtaining the results of the first variety trial. The greatly increased numbers of seedlings that the proposed method of selection would enable to be handled should more than compensate for the extra time that it would involve.

Possible Variety Developments of the Future

It has never been easy to make an accurate prediction of future variety developments: it is particularly difficult to do so at the present time. This is because the possibility has now arisen that varieties on the decline may—by treating them for ratoon-stunting disease—be given a new lease of life.

The following are the likely changes in the proportions of the three main varieties of Natal. Co.301 has probably passed its peak and the area under it can be expected to decline. Both Co.331 and N:Co. 310, however, seem likely to increase in importance during the next few years—N:Co.310, of course, continuing to occupy the more extensive acreage.

Of the recently released varieties, N:Co.293 is adapted to the higher altitude regions; it will probably increase rapidly in these regions until it covers quite an extensive area. It is not likely to prove popular in the main coastal belt because of its tendency to flower very profusely, even during its first year's growth. The future of the variety N:Co. 339 is likely to depend upon its reaction to mosaic disease. It appears that N:Co.339, though retaining its tolerance to this disease, may have become more susceptible to infection. Nevertheless, the chances are that this high-yielding, versatile variety will prove of value in many parts of the main coastal belt.

The variety N:Co.292, to be distributed soon, may find its niche within specialised areas of the cane belt, but it does not have the same chance of coming into general cultivation as the other N:Co. varieties.

Varieties at Present under Trial

Now that seedlings can be selected in Natal for their adaptation to local conditions, established varieties from overseas are less likely to qualify for general cultivation. The only imported variety at present in a variety trial is M.63/39. Future variety releases are most likely to come from seedlings raised in Natal—from either local or imported seed.

The position with regard to seedlings raised from introduced seed is now as follows. There is little likelihood that more commercial varieties—unless they are highly specialised—will be obtained from the particular batch of seed that produced the varieties already released. This particular introduction, however, was followed by many others—eight from Mauritius, two from Queensland, one from India and one from Hawaii.

The introduction from India consisted of a further supply of seed from three crosses which had previously proved promising in Natal. The most promising varieties obtained from this introduction are N:Co.376 and N:Co.382. One or both of these varieties may later on qualify for release. N:Co.376 has the same parentage as the N:Co. varieties already released—that is, Co.421 × Co.312. N:Co.382 comes from the cross P.O.J.2725 × Co.301.

The seed introduced from Mauritius and Hawaii did not prove as valuable as that from India. All the seedlings that were raised from this seed have now been discarded.

The seedlings raised from Queensland seed are still under trial. Only two of the first batch of seedlings now remain—they are in a variety trial. Fifty-three of the second batch are planted in single lines.

There is no chance of any varieties from crosses made locally being released in the immediate future. An indication of the position at present reached in sugarcane breeding in Natal can be obtained from the following table:—

Year Seedlings Germinated	NUMBER OF SEEDLINGS		
	Planted as Single Stools	Selected for Single Lines	Selected for Variety Trials
1944 ...	36	14	0
1945 ...	572	30	7
1946 ...	681	58	5
1947 ...	54	5	0
1948 ...	2,868	175	14
1949 ...	13,331	1,099	—
1950 ...	11,141	580	—
1951 ...	8,183	250	—
1952 ...	25,432	—	—
1953 ...	32,192*	—	—

* An additional 30,000 seedlings were planted in bunches

As shown in the table, only twenty-six seedlings of local origin have reached the stage of being tested in a variety trial. Of the 1945 and 1946 seedlings, only one out of twelve was selected for further testing. The 1948 seedlings were only recently planted in a variety trial and no results are as yet available. Up to the present, selections for variety trials have been made from relatively few seedlings. Next season, however—and, one may reasonably hope, from then on—fairly large numbers of seedlings should be available for testing in variety trials. The seedlings which will be tested next season were raised in 1949—the first year that more than a few thousand seedlings were obtained.

In conclusion, therefore, it may be said that although there is no immediate prospect of the release of any locally-produced seedlings, the large number at present under trial offers hope for the future.

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Dr. McMartin (Chairman) stated that it would be remembered that it was not many years ago when it was thought impossible to produce any seedlings in Natal. It had only become possible in recent years to plan a cane breeding programme under South African conditions. This work was also of interest to other countries, for example, Louisiana, which had similar conditions to ours.

Mr. Jex asked if the original discarding of seedlings was from seedlings grown on special soil. Might it be advisable for original seeding to be done in the various soil types in the sugar belt, since varieties shewed either affinity or antagonism to different soils.

Mr. Brett replied that this was a subject which they would like to explore further. Up till now seedlings had been tried out only on Experimental Station soil, which was the only land available for this purpose.

Mr. Rault asked for further information about the susceptibility of the variety N:Co.339 to mosaic. He asked what was meant by the future of the mosaic spread in this variety which represented 24 per cent. of his Company's planting programme this year.

Mr. Brett said that the variety N:Co.339 had very seldom been found infected with mosaic during its early years of trial at the Experiment Station. The incidence of this disease seemed to have increased somewhat in recent years, but yields in this variety appear to be only very slightly reduced by mosaic infection.

Mr. Barnes said that in view of the increase in sugar production in Natal at present, which could be expected to be greater in the future, was attention paid to the peak period of maturity in the

various varieties when carrying out these tests before varieties were discarded?

Mr. Brett replied that seasonal sucrose tests were regularly carried out.

Mr. Du Toit said that although such tests had been done in the past, he thought that more intensive study from this point of view was necessary. He remarked upon the one batch of seedlings from India, which had produced such a large number of promising varieties, some of which, e.g. N:Co.310, N:Co.339, N:Co.292 and N:Co.293, had been released. He would like to know what proportion of the seedlings now being raised consisted of the same cross.

Mr. Brett replied that about a thousand seedlings of this cross had been raised locally. As far as could be judged from seedlings in the early stages of selection, the cross of Co.421 with Co.331 appeared to be as promising a one as that of Co.421 with Co.312.

Dr. Dodds said that some time ago it was suggested that we should try to raise more seedlings from the crosses which had produced Co.281 and Co.290. He would like to know if this policy was yet being followed. He had seen that in a certain case in East Africa, N:Co.339 had survived under conditions of neglect and drought in a way which was really remarkable.

Mr. Brett said that the crosses referred to could not be made locally, as some of the parent varieties were not available, and others, though available, did not flower under Natal conditions.

Dr. Douwes Dekker asked if only sucrose per cent. cane or tons of sucrose per acre were taken into account when the merits of new varieties were judged or if other desirable factors from a manufacturing point of view were also considered.

Mr. Brett said that such qualities were not lost sight of although they could only be tested out in the later stages of selection.

Mr. Jex enquired what was known of the affinity of certain cane varieties to certain soil types.

Mr. Brett said that nothing along these lines had been attempted in the way of pure research.