METHODS OF CANE BREEDING USED BY THE QUEENSLAND
BUREAU OF SUGAR EXPERIMENT STATIONS

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INTRODUCTION

From the period 1938 to 1947, cane breeding work performed by the Queensland Bureau of Sugar Experiment Stations was conducted mainly by the Division of Pathology. The methods used at that time and their development have been fully described by Hughes. A reorganization at the end of 1947 gave plant breeding the status of a separate division, and since that time there have been gradual changes both in technique and in basic methods.

TECHNIQUE

Since as long ago as 1937, practically all the cross-pollination has been done by the Hawaiian method of crossing in solution. This is, to a large degree, dictated by a necessity to make the greatest use of the available labour which, in comparison with that of many countries, is limited by cost. It was also by a desire to keep the whole cane breeding operation as compact as possible. Both male and female arrows are excised from the plant and maintained in solution, the constitution of which has been changed on several occasions, and at the present time consists of a water solution containing 150 p.p.m. of sulphur dioxide and 85 p.p.m. of orthophosphoric acid. Experiments with other chemicals have not proved successful and, since the cane flowers cross-pollinate and set seed quite easily in this solution, it does not appear justifiable to spend a lot of time in developing an alternative chemical to perform the same duty. The former technique of leaving most of the leaves on the flowering stalks, cutting off a section of stalk and changing solutions every second day, has been discarded in favour of the more effective and far less laborious method of stripping all leaves except the flag leaf from the stalks, changing the solution twice per week and cutting off only once, when cross-pollination is complete and the female arrows are transferred to the ripening rack.

USES OF LANTERNS

Fabric lanterns to protect crosses from stray pollination were introduced to the breeding programme in 1939, and until 1956 some of the crosses were made under lanterns and the remainder were maintained dispersed at intervals in the open forest to reduce pollen contamination. Until 1956, the lanterns were made of voile, a light, open-mesh, cotton material, designed to keep out pollen but to allow the circulation of air. However, in developing our research programme, it was found that fairly serious contamination was occurring both in the open crosses and in the voile lanterns. In consequence, more closely woven materials have lately been used for the lanterns and open crossing has been discarded. The whole of the cross pollination is now conducted in a battery of some 170 lanterns and contamination has been reduced to a negligible figure, a highly desirable state if an effective research programme is visualised.

It should be pointed out here that the original voile lanterns were not introduced
to the crossing programme without due testing, but since they were originally developed many more parent canes have been acquired from some of which, notably the *robustum* 51N.G. 63, the pollen seems to be particularly prone to enter where it is not desired. Some idea of the degree of contamination which is possible may be gauged by the fact that in experiments conducted by Skinner, no less than 700 seedlings were raised from 10 grams of fuzz collected from male-sterile flowers enclosed without male arrows in a voile lantern, and as many as 500 from similar flowers in the open forest at the normal distance of dispersal. The effect of this severe contamination was to throw all self-pollination into doubt, including the production of selfs for a selfing-backcrossing programme. It also provided an explanation for many of the anomalies which have appeared in the past when, for instance, vigorous seedlings were produced in a particular year by a cross which customarily produced seedlings lacking in vigour. It was noteworthy that when selfing was done in glassine bags, the progeny lacked vigour when compared with seedlings from selfings made in voile lanterns.

The contamination from stray pollen has had some bearing on the methods of cane breeding now used by the Queensland Sugar Experiment Stations. Until it is assured that reasonably large populations of indisputable selfs can be developed, it is felt that it would be unwise to devote much time to the method of selfing when it must be done at the expense of the progeny testing method which has yielded outstanding results in the production of commercial varieties. The drawbacks of a selfing programme have been adequately dealt with by Mangelsdorf. Whilst we do not consider that there is the same likelihood for improvements from a selfing programme in sugar cane as there is in a seed-propagated plant, we do not feel that the method should be ignored. However, it is regarded as part of the experimental programme rather than a proven method until it is certain that so-called selfs are free from any possibility of contamination.

In the meantime, work is concentrated on the proven cross system and all possible methods are being used to accelerate this work. Some of these methods are as follows:

(a) The polycross (equivalent to the melting-pot of Hawaii) is used firstly, for producing a large amount of seed for use in bunch planting and for storage as an insurance against a poor crossing year; secondly, as a means to determine rapidly the combining ability of prospective new parent varieties.

(b) The area cross, which is a bulk method of using one male variety to pollinate a number of male-sterile, seed-producing parents, is exploited when possible. Its use is limited by the comparative scarcity of absolutely male-sterile varieties which are desirable as parents in this type of cross.

(c) Bunch-planting, as well as being used to some extent in the commercial variety programme, is also being used as the most rapid method of breeding-in new blood lines. For example, it has been freely used in breeding-in the *robustum* clones collected by the 1951 New Guinea expedition. In this work it is found desirable to test large numbers of parent canes from each successive generation, and bunch-planting has proved a useful aid for this purpose.

**INDUCTION OF TASSELLING AND SYNCHRONISATION OF FLOWERING**

Most sugar cane varieties flower in the Queensland parent plots and desirable parents which seldom flower are used to the greatest possible extent in the odd years in which they do produce flowers. Desirable parents, which rarely or never flower in

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Queensland, are mainly of the purely noble group, and it is yet to be demonstrated that such varieties can be made to flower by artificial manipulation. A small room is used for photoperiod induction of flowering, and at least one variety has been induced to flower out of season by the method of Chilton and Paliatseas. However, it is felt, for our purposes, that where ample flowers of most required varieties are available, the artificial induction of flowering is too time-consuming at a period when all available labour is fully occupied. Synchronisation of flowering is achieved, however, by the use of artificial lighting, maleic hydrazide sprays and lopping of foliage. These all give similar results and are used in normal cross-pollination. So far, without resort to more difficult and time-consuming methods, it has been possible to effect sufficient crosses with spontaneum clones which do not normally flower in season with the noble and near noble varieties.*

INTERSPECIFIC HYBRIDIZATION

Spontaneum blood lines have always been of great value in the production of commercial varieties in Queensland and of late, attention has been concentrated on the further nobilization of Burma spontaneum hybrids. This clone appears the most promising of all spontaneums and the hybrid E.P.C. 38-304 (P.O.J. 2725 × S. spontaneum Burma), which develops ample fertile pollen, has promise as a useful parent in Queensland.

On account of its resistance to both flooding and waterlogged soils in its natural habitat, it has always appeared that the species Saccharum robustum should confer valuable characters for North Queensland commercial varieties. Although the robustum clones of the 1928 New Guinea expedition were used for years, it was not until 1958 that the first variety with robustum in its parentage was approved. This is the variety Q. 66, which was developed from 28N.G. 251 as a great-grandparent and has shown outstanding resistance both to flooding and lodging. More recently extensive use has been made of the robustum varieties of the 1951 New Guinea collection, and of these, 51N.G. 63 and 51N.G. 140 now appear to offer the greatest promise. They are both vigorous, good males, and 51N.G. 140 stools more profusely than most varieties of robustum. This fact may be important because lack of stooling has often been a weakness in hybrid populations developed from robustum. Although odd clones of Miscanthus and Erianthus are in the breeding collection, these genera have not been used in the breeding programme.

SEED STORAGE

Fuzz is packed in individual heat-sealed “polythene” bags, with calcium chloride included in each bag as a drying agent. For long storage, these bags are packed into airtight tins, some 40 bags to a tin. Seed is planted as soon as possible after it is ripe which, at three of the seedling-raising stations, is within 3 weeks of packing. For this short period, the seed is stored in a refrigerator at 0° to 5° C. At the fourth station, seed is not germinated until some 7 months after it is ripened. This seed, together with all reserve stocks of seed, is stored at a temperature of —15° to —18° C. The reserve stocks are used to ensure an adequate supply of seed in a bad crossing year, and experience shows that it will germinate quite well after 3 years of storage at the low temperature.

* See addendum to this paper for more details of synchronization techniques.
SUMMARY

All cross-pollination done by the Queensland Bureau of Sugar Experiment Stations is now effected in solution, and until the pollination is complete the crosses are maintained under pollen-proof lanterns. Extensive tests in 1956 and 1957 showed that, under voile lanterns and in uncovered crosses dispersed through an open forest area, pollination with stray pollen could be severe. This implies that all previous selfs as well as the male parentage of some commercial and parent varieties are suspect. Lanterns developed in 1956 and completely erected in the headland Leads are taken from the two outlets and led to a pole on the headland. Leads are taken from the two outlets and led to lights attached to temporary poles erected in the cane field in suitable positions. In this installation each pole is provided with a 300-watt clear electric globe, attached about 12 feet above ground level. The time switch is set to turn on about midnight and off some 20 minutes later. This period could be shorter, but is the minimum possible with the type of time switch used. The lighting system is switched on towards the end of February and switched off towards the end of April. Using this method, arrowing is almost completely inhibited in close proximity to the lights until toward the end of June, but arrows develop progressively earlier in stalks further away from the light's influence, and it is possible to obtain a convenient series of flowers ranging from the normal flowering period of the variety until late in the average flowering season.

(1) Artificial Lighting.

This is the preferred method but is limited to those varieties which are in easy access to a lighting system. At the Northern Sugar Experiment Station a small block, about one-quarter of an acre in area, is utilized for the purpose. The lighting system takes its power from the 250-volt district supply, which is fed to a time switch provided with two outlets and attached to a pole on the headland. Leads are taken from the two outlets and led to lights attached to temporary poles erected in the cane field in suitable positions. In this installation each pole is provided with a 300-watt clear electric globe, attached about 12 feet above ground level. The time switch is set to turn on about midnight and off some 20 minutes later. This period could be shorter, but is the minimum possible with the type of time switch used. The lighting system is switched on towards the end of February and switched off towards the end of April. Using this method, arrowing is almost completely inhibited in close proximity to the lights until toward the end of June, but arrows develop progressively earlier in stalks further away from the light's influence, and it is possible to obtain a convenient series of flowers ranging from the normal flowering period of the variety until late in the average flowering season.

(2) Maleic hydrazide.

Where it is desired to delay the flowering of varieties which have not been planted in the range of our artificial lighting system, a maleic hydrazide spray is generally used. This is applied to the foliage of the cane with a knapsack spray as a 1% solution. It is usually applied in late January or early February, but must be applied reasonably early or the results will be poor. The method has the advantage of being simple and unlike the lighting method it is not restricted to varieties planted in a pre-determined position.

(3) Lopping the Foliage.

Lopping the foliage was the first method used extensively in Queensland to delay the flowering time of parent canes, and for a number of years was the only method used. The foliage is bundled and removed with a sharp knife some 3 to 4 inches above the youngest exposed dewlap. Lopping is necessary only once for some varieties, but for others a second lopping is required. The first lopping is made at the end of January, and if a second one is required it is done a month later. Since the lopping method requires more labor than either of the other two methods, it has now been superseded by them and is seldom practiced now.

REFERENCES


ADDENDUM

Since some cane breeders may be interested in more intimate details of the methods used to delay flowering in Queensland, a brief description of these follows. It should be borne in mind that the normal flowering period in Queensland for most varieties is from mid-May until the end of June.

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Any of the 3 systems achieves a wide range of flowering stalks commencing from the normal flowering period of the variety concerned. Although it is likely that the greater number of affected stalks flower about a fortnight later than usual, in some individual stalks the flowering is delayed for up to several weeks, and this enables crosses with late flowering varieties to be effected with ease.

SUGAR-CANE BREEDING METHODS*

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In the history of sugar-cane breeding, the Java variety P.O.J. 2878 stands out as a major achievement. Both as a commercial variety in its own right and as a parent of commercial varieties, it has established a remarkable record. All of the present commercial varieties of Hawaii, as well as those of many other regions, are descendants of P.O.J. 2878.

In view of the importance of P.O.J. 2878 to the sugar industry, a review of its pedigree may be of interest.

PEDIGREE OF P.O.J. 2878

Bandjermasin Hitam
(Original noble)
from Borneo

\[ x \]

P.O.J. 100
(From an open-pollinated tassel collected by WAKKER—1893)

? P.O.J. 2364
(WILBRINK 1911)

Unknown noble

\[ x \]

Kassoer
(Collected in the wild about 1890)

P.O.J. 2878
(JESWIEC 1921)

Unknown Glagah
(S. spontaneum)

The recorded pedigree of P.O.J. 2878 begins in 1893, when J. H. WAKKER grew a population of seedlings from an open-pollinated tassel of Bandjermasin Hitam. From this population he selected P.O.J. 100. Bandjermasin Hitam is a dark-colored variety from Borneo. It is a typical "noble" cane, a term first used by the Dutch breeders in Java to designate the large-stalked sweet canes of the species Saccharum officinarum.

The history of the origin of Bandjermasin Hitam itself, like that of the other "original" noble varieties, is hidden in the mists of sugar-cane antiquity. The evidence suggests that the noble canes owe their existence to domestication by primitive man. It is reasonable to assume that mutations of various kinds must have occurred from

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