

SELECTING MOSAIC RESISTANT SUGARCANE VARIETIES FOR THE NATAL MIDLANDS

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Abstract

Since 1968, all stages of the variety selection programme for the Natal midlands had been carried out on sites in that area. The programme was modified in 1981, to allay fears that varieties tested under relatively good conditions at Windy Hill might fail in less favourable areas. Various procedures were introduced to increase the proportion of mosaic resistant varieties surviving to the later stages of the programme. The achievements of these procedures are examined, with particular reference to obtaining mosaic resistant varieties. Suggestions for possible improvements to the programme are made.

Introduction

Until 1968, the variety selection programme for the Natal midland areas was dependent on the testing of selections made at Mount Edgecombe for their suitability for the midlands. The site where much of this work was done was Powerscourt in the Mid-Illovo area. It was realised that progress towards obtaining varieties suited to the special conditions of the Midlands, would be enhanced if all stages of the programme were conducted in that environment. In 1968, a site for this purpose was established at Windy Hill and a selection programme, based on 7 250 seedlings, was initiated.

The varieties NCo376 and NCo293, that comprised most of the cane grown in the area at that time, were very susceptible to mosaic. Thus, in addition to high yield potential, varietal resistance to mosaic became an important selection criterion for the midlands selection programme.

In this paper, some results of the selection programme are reviewed. In addition, the effects of new procedures introduced to improve the efficiency of the programme, have been examined.

Basic selection programme

The initial selection programme at Windy Hill was designed to follow a schedule similar to the Mount Edgecombe programme, while allowing for the longer cropping cycle in the midlands. The main features of the programme are shown in Figure 1.

For the purpose of selecting new varieties for the South African sugar industry, the cane growing areas have been divided into three regions. The programme for the northern irrigated areas is based at Pongola. The southern rainfed areas have separate programmes at Mtunzini, Shakaskraal and Mount Edgecombe. The midland areas are served by the programme at Windy Hill (now moved to Bruyn's Hill).

Mosaic screening procedures for the selection programme have been described by Bailey and Bechet, (1982). Figure 1 shows how trials relate to the selection programme. The ratings for mosaic resistance determined in the screening trials, for varieties derived from the midlands programme, were compared with varieties derived from both the northern irrigated and the southern rainfed programmes.

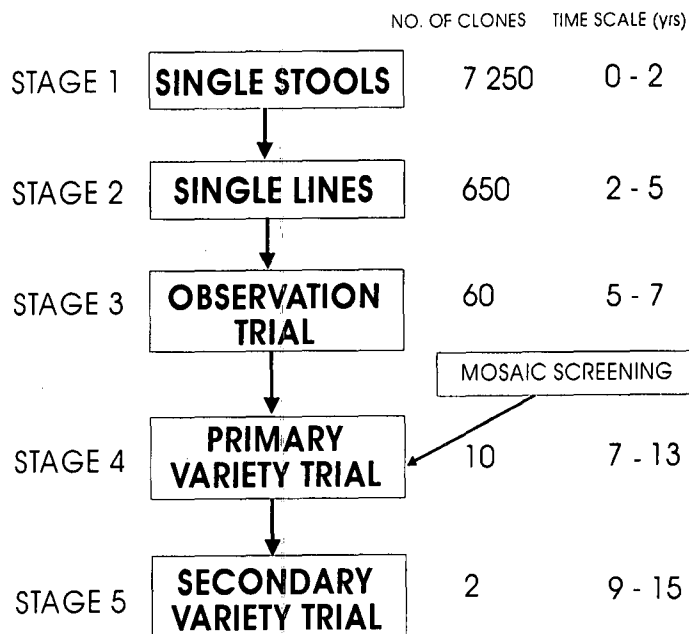


FIGURE 1 Flow diagram of the midlands selection programme.

Changes made to the midland's programme

Additional sites

The Windy Hill site was chosen because it represented a major soil type (Inanda form) in the midlands. The long term mean rainfall was 1 017 mm - slightly better than average for the area. During the late 1970s, a decision was made to supplement the midlands programme with two satellite stations to test varieties under a wider range of conditions than those found at the Windy Hill site. At Windy Hill the incidence of mosaic was slight, and it was decided to test varieties in an area where the incidence of mosaic was high. A site for this purpose was established at Eston.

There was also a need to expose potential new varieties to less favourable growing conditions than those at Windy Hill. Although a site on a Cartref form soil was considered best for this purpose, the presence of 'isidulis' in these soils made the area variable and unsuitable for variety trial work. After consultation with the Extension department, a site in the Sevenoaks areas was selected as representative of harsher conditions than Windy Hill. Starting in 1981, selections due for planting in the primary variety trial (stage 4) at Windy Hill were also planted at Eston and Sevenoaks. Each year, ten to fourteen varieties from the Windy Hill programme have become available for testing at this stage. Only two varieties from stage 4 would normally be evaluated for possible release (Figure 1). Trials on the satellite sites would ensure that no variety with possible adaptation to other midland environments would be discarded without thorough testing. In addition, the exercise might provide valuable information on the interaction between varieties and different environments.

Early results from the Eston primary variety trials indicated that some varieties that had shown acceptable resistance to mosaic at Windy Hill or Sevenoaks, were unacceptable. As at least seven years are required to develop varieties to the primary variety trial stage, it was clearly inefficient to lose varieties at this late stage because of their inadequate disease resistance.

Single stool selection

1983 single stools

To screen out mosaic susceptible varieties early in the selection programme, it was decided to grow single stools (stage 1) at Eston, where there was a high incidence of the disease. It was expected that stools that did not show symptoms of mosaic would be resistant to the disease. A selection strategy, known as 'cross assessment', had been developed at Mount Edgecombe to obtain improved sucrose content in the variety programme, (Bond, 1977; 1989). The method was based on the determination of average sucrose content for an entire sugarcane cross and selecting only individuals from those crosses that showed high sucrose content.

There was a possibility that a similar strategy would work to improve mosaic resistance early in the selection programme. To test these two hypotheses, single stools were planted at Eston in addition to the routine planting of single stools at Windy Hill. The progeny from 25 biparental sugarcane crosses were planted in plots consisting of one row 8 m long. Seedlings from each cross were planted 0,5 m apart in the row, allowing 16 seedlings per plot. Depending on the number of seedlings available, two or three plots of each cross were planted. Planting was done in spring 1983, and the stools were cut back in August 1984 and allowed to ratoon. Disease inspections were carried out and a record kept of all stools showing mosaic. The percentage of diseased stools was used to rank the crosses in order of disease susceptibility.

About 15% of the stools from this trial were selected on a basis of estimated yield and freedom from mosaic symptoms. Ten stalks from each of the selected stools were planted into the routine programme as single lines at Windy Hill. The Windy Hill single line trial contained 129 lines derived from the Eston trial and 709 derived from single stools grown in the regular programme at Windy Hill. The single lines were inspected in the plant and ratoon crops and the number of lines showing mosaic symptoms from the two sources was compared.

1985 trial

In 1985, 800 seedlings from 23 biparental crosses were planted at Eston as single stools. All diseased stools were cut down and stools with the highest estimated cane yield were selected from the remaining stools. In this instance, no record was kept of the number of stools showing mosaic symptoms, so it was not possible to obtain the number of mosaic infected stools for the different crosses. Sixty selections (7% of the total) were planted in 8 m lines at Bruyn's Hill, adjacent to the routine single line trial (274 lines). Plant and first ratoon crops of this trial were inspected for disease and the number of lines showing mosaic symptoms were compared, depending on whether they had originated from Eston or were from the single stools at Bruyn's Hill.

Results

Midlands selection programme

Varieties tested in the mosaic screening trials during 1986 to 1991 were grouped according to whether they were de-

rived from the northern, southern or midlands selection programmes. Varieties imported from other countries during this period made up a fourth group. For each selection programme, the percentage of varieties in each of three mosaic categories was obtained from the Pathology department screening trials. The results are shown in Table 1.

Table 1

Percentage of varieties assigned to three mosaic resistance categories according to the selection programme from which they were derived

| Source of varieties (programme) | Resistant (%) | Intermediate (%) | Susceptible (%) |
|---------------------------------|---------------|------------------|-----------------|
| Midlands | 70 | 21 | 9 |
| Northern | 36 | 26 | 38 |
| Southern | 41 | 21 | 38 |
| Imported | 13 | 22 | 65 |

The midland variety programme has proved to be highly successful in selecting varieties resistant to mosaic. Some 70,5% of the midlands selected varieties (H series) were rated as resistant, and 90% of the H series have a resistance rating equal to or better than N12. The percentage of varieties derived from the midlands area programme that are resistant to mosaic, is double those emanating from either the northern or southern programmes.

The fourth group of varieties was drawn from several different overseas breeding programmes, including USA (Canal Point), Mauritius, Reunion and Queensland. The high susceptibility of this group would be cause for concern, if South Africa were dependent on imported varieties for its sugar production.

Additional sites

A major reason for increasing the number of testing sites for the primary variety trials, was the belief that varieties might rank differently in yielding ability according to the site. The cane yield for plant cane, first and second ratoon crops for the 79H and 81H series of varieties was averaged for each of the three sites. The varieties were then ranked on this average for each site in turn. The ranking of the varieties is given in Tables 2 and 3. The 79H series of varieties was selected at the Windy Hill site and the 81H series was selected at the new Bruyn's Hill site.

Table 2

Cane yield and ranking for 79H series of varieties at three midland sites (WH = Windy Hill, PH = Eston, SN = Sevenoaks)

| Variety | Yield (tons/ha) | | | Ranking | | |
|---------|-----------------|-----|-----|---------|----|----|
| | WH | PH | SN | WH | PH | SN |
| 79H0084 | 112 | 101 | 108 | 1 | 5 | 6 |
| 79H0143 | 106 | 110 | 118 | 2 | 3 | 4 |
| 79H0152 | 100 | 96 | 107 | 3 | 7 | 7 |
| 79H0161 | 99 | 117 | 123 | 4 | 1 | 1 |
| 79H0181 | 92 | 114 | 119 | 6 | 2 | 4 |
| 79H0240 | 95 | 103 | 119 | 5 | 4 | 2 |
| 79H0274 | 76 | 78 | 81 | 11 | 12 | 12 |
| 79H0328 | 85 | 83 | 104 | 8 | 11 | 8 |
| 79H0338 | 80 | 96 | 111 | 9 | 6 | 5 |
| 79H0374 | 67 | 85 | 70 | 12 | 9 | 13 |
| 79H0426 | 88 | 76 | 101 | 7 | 13 | 9 |
| 79H0469 | 79 | 92 | 100 | 10 | 8 | 11 |
| 79H0678 | 66 | 84 | 100 | 13 | 10 | 10 |
| MEAN | 88 | 95 | 105 | | | |

Table 3

Cane yield and ranking for 81H series of varieties at three midland sites (BH = Bruyn's Hill, PH = Eston, SN = Sevenoaks)

| Variety | Yield (tons/ha) | | | Ranking | | |
|---------|-----------------|-----|-----|---------|----|----|
| | BH | PH | SN | BH | PH | SN |
| 81H0021 | 100 | 74 | 100 | 5 | 6 | 6 |
| 81H0062 | 110 | 104 | 120 | 3 | 3 | 2 |
| 81H0124 | 96 | 83 | 113 | 6 | 4 | 4 |
| 81H0209 | 96 | 67 | 100 | 7 | 7 | 7 |
| 81H0214 | 83 | 66 | 98 | 10 | 8 | 8 |
| 81H0254 | 120 | 108 | 128 | 1 | 2 | 1 |
| 81H0262 | 94 | 62 | 90 | 9 | 9 | 9 |
| 81H0271 | 95 | 61 | 81 | 8 | 10 | 10 |
| 81H0297 | 100 | 76 | 105 | 4 | 5 | 5 |
| 81H0433 | 114 | 108 | 117 | 2 | 1 | 3 |
| MEAN | 101 | 81 | 105 | | | |

The ranking of the varieties at the three different sites was similar in each of the two series chosen. The rankings did not give any indication of the magnitude of differences between varieties, and the cane yield was plotted for each site against each variety (Figures 2 and 3).

**MIDLANDS SATELLITE SITES
79H SERIES**

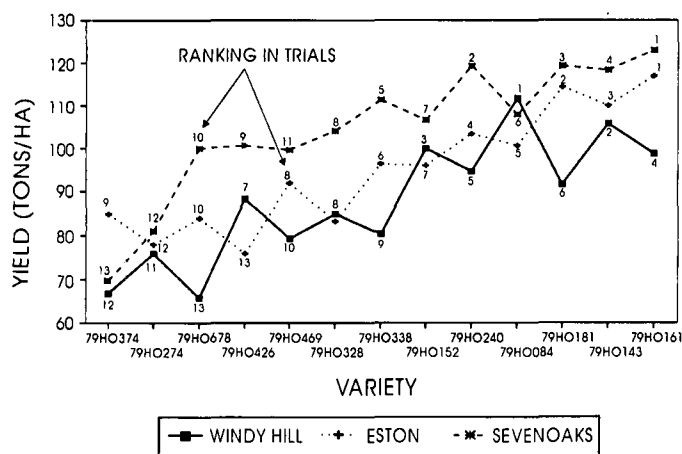


FIGURE 2 Cane yield and trial ranking obtained for three sites plotted against varieties of 79H series.

**MIDLANDS SATELLITE SITES
81H SERIES**

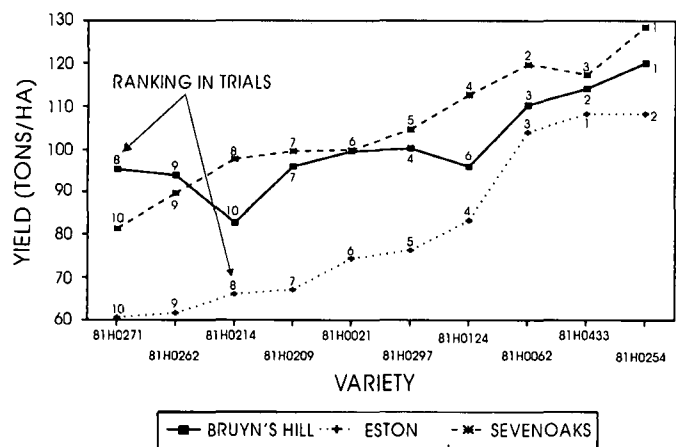


FIGURE 3 Cane yield and trial ranking obtained for three sites plotted against varieties of 81H series.

Despite overall similarity, there were some interesting differences. Variety 79H0084 was ranked first at Windy Hill but only fifth at Eston and sixth at Sevenoaks. The variety 76H0181 was low yielding at Windy Hill, but second at Eston and third at Sevenoaks.

The 81H series of varieties had a lower average yield at Eston than at either Bruyn's Hill or Sevenoaks (81, 101 and 105 tons/ha respectively). The varieties under rank three at Eston had markedly lower yields than the same varieties at the other sites (Figure 2).

It may be concluded that, for the purpose of ranking varieties according to cane yield, there is little advantage in testing varieties on three sites in the midlands. However, as regards diseases, the sites often showed distinct differences. In 1987 many varieties in the variety trials at Sevenoaks showed symptoms of red rot, but the same varieties were unaffected at the other sites. It was possible to demonstrate dramatic yield losses due to red rot, and the Pathology department subsequently launched a project to investigate the occurrence of the disease in the midlands (Trenor and Bailey, 1989).

Reference has been made to the high incidence of mosaic recorded at Eston. Comparing the same varieties at Windy Hill, Eston and Sevenoaks over five years, 23% had at least one recording of mosaic at Windy Hill, 70% at Eston and 37% at Sevenoaks. In a separate comparison, over six years, 37% of the varieties showed mosaic at Bruyn's Hill, 70% at Eston and 42% at Sevenoaks.

Single stool selection

1983 single stools

The trial was inspected for mosaic in May 1985, and the crosses ranked according to the total number of stools showing the disease. The overall level of infection was lower than expected, being only 16% of the total number of stools in

Table 4

Parentage of crosses grown in the 1983 trial at Eston and mosaic recorded at Eston and Windy Hill

| Cross No. | Parentage | Eston (% of stools showing mosaic) | Windy Hill (line) |
|-----------|--------------------|------------------------------------|-------------------|
| J946 | N10 × N6 | 0 | |
| L1087 | N10 × N11 | 3 | * |
| M713 | N55/805 × N12 | 6 | * |
| M889 | N12 × N13 | 6 | * |
| O1075 | 76F1553 × N12 | 0 | |
| O440 | N18 × N55/805 | 13 | |
| O48 | 72E1045 × N17 | 0 | |
| P1127 | N52/451 × CP63/588 | 6 | |
| P183 | 74M0411 × N15 | 31 | |
| P234 | N18 × 74F2243 | 9 | Nil |
| P836 | N12 × N14 | 9 | |
| P1009 | 75L659 × 75L1157 | 13 | * |
| R1043 | 76F399 × N14 | 19 | Nil |
| R1148 | NCo293 × 73H308 | 0 | * |
| R194 | N20 × CB36/14 | 3 | |
| R195 | 72M1482 × CB36/14 | 6 | |
| R294 | N11 × 72M1474 | 0 | |
| R399 | 75L1157 × 78L2091 | 9 | * |
| R445 | N20 × 78L2091 | 19 | |
| R451 | 72F2530 × N15 | 19 | |
| R491 | 69E991 × 78L2091 | 9 | * |
| R658 | 69E991 × N7 | 0 | * |
| R77 | NCo376 × CB36/14 | 25 | Nil |
| R816 | 76F1535 × CP63/588 | 8 | |
| R85 | 70M457 × 73H308 | 5 | * |

* Mosaic recorded in single lines
Nil - No selections in the cross

the trial. There were, however, apparent differences between crosses, and the percentage of stools showing mosaic in each cross is given in Table 4. Cross numbers and parentage of the crosses are also shown.

The most susceptible cross was P183 (74M0411 × N15), with 31% of the stools having mosaic symptoms. There were several crosses where none of the stools showed mosaic symptoms.

Only 7% of the 129 lines planted at Windy Hill showed mosaic. Occurrence of mosaic at Windy Hill did not appear to be related to high or low percentages of diseased stools at Eston. Crosses that were recorded with mosaic in the single lines are indicated by an asterisk in Table 4. No single lines derived from the very susceptible cross P183 were recorded as having mosaic, but mosaic was recorded in R658 and R1148, which were free of mosaic in single stools.

1985 single stools

When grown as single lines at Bruyn's Hill, 26% of those derived from single stools at Eston showed the disease, whereas 20% of those selected at Bruyn's Hill showed symptoms. The small difference between the two groups is unlikely to be of any significance.

Discussion

The work of the Plant Breeding department is primarily to select new varieties. The selection trials are designed to do this with the greatest efficiency that resources will allow. The routine trials of the selection programme are less suited for making comparisons of the kind reported in this paper. At the early stages of selection there is no replication of varieties, and stages in the programme are often grown in widely separated fields. Clearly environmental effects are likely to be large and without replication these effects cannot be measured satisfactorily. Nevertheless, we believe that the observations are worth reporting as they cast some doubt on the value of selecting for mosaic resistance at the single stool stage of the programme. Selecting single stools at Eston was ineffective in increasing the proportion of resistant clones in the single line stage, and there could be several reasons for this.

Due to the relatively small amount of plant material presented in a single stool, the possibility of infection taking place is poor. In the mosaic screening trials, not only are varieties replicated, but each variety is represented by 15 m of row. Some varieties that did not get infected with mosaic

in the screening trials were recorded with the disease in the primary variety trials at Eston. A variety in one of these trials is represented by 120 m of row, thus increasing the prospect of infection. It must be emphasised that screening for resistance is not merely checking for the presence or absence of a disease. To obtain the rating of a variety, the results of the trial must be interpreted using the reaction of a range of known standard varieties.

It is known that time of planting is an important factor in the incidence of mosaic (Bailey and Fox, 1980) and it is not always possible for yield selection needs to coincide with those for the best mosaic screening. The low incidence of mosaic in the Eston stools was perhaps partly due to the timing of planting and the cutting back of the stools in August rather than in November.

Conclusions

Ranked on cane yield, it appears that varieties have a similar order of merit when grown on three midland satellite sites. There is some duplication of effort in the programme. Although the programme has achieved its objective in terms of resistance to mosaic, there is also a need to increase the level of resistance in the northern and southern area programmes. However, the following points need to be considered. It would appear that screening at the single stool stage is not effective. To screen all clones at stage 2 of the programme would require an area of about 40 ha, assuming that a 15 m row per variety is required to do this effectively. Screening all stage 3 selections would require four to five hectares of land and the Eston site might be used for this purpose.

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