FACTORS INFLUENCING THE NUMBERS OF SEEDLINGS OBTAINED FROM SUGARCANE CROSSES

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Abstract

Reasons for low numbers of seedlings from crosses made in recent years were investigated. High temperature and low humidity at the time of pollination decreased seedling numbers in some years. Photoperiodism, time of flowering and nutrition could also have affected the numbers of seedlings obtained.

Introduction

Improved seed set in sugarcane flowers have been obtained at the Experiment Station by placing developing flowers in a heated glasshouse (Brett[2], Brett[3]). Recently in Australia light bulbs were placed in crossing lanterns to improve the numbers of seedlings obtained from crosses (Anonymous[1]). Higher temperatures (±30°C) at the time of seed germination gave more seedlings than temperatures below 30°C (Unpublished data). In Hawaii, the optimum temperature for seed germination was 38°C (Heinz[6]).

Crosses made at Mount Edgecombe prior to 1974 generally gave more than 400 seedlings per cross. However, the average numbers of seedlings obtained from crosses made from 1974 to 1978 varied from only 205 to 269. This reduction in seedling numbers resulted in too few seedlings being obtained from some important crosses, so that more crosses had to be sown than previously. This paper deals with some of the reasons for the low seedling numbers obtained in recent years.

Procedure

The handling of flowers at the time of crossing and the sowing of seed follows a regular pattern. No alteration in these procedures has been made in the period covered by this study.

Stalks grown in the photoperiod facilities are cut when the flowers emerge, a container with rooting mixture is placed on the lower part of the stalk (marcotting) and the base of the stalk is immersed in a sulphur dioxide crossing solution. The stalks are removed from the solution after two weeks. Stalks from cane growing in the field are marcotted when the first signs of flowering are seen. These stalks are kept in the glasshouse with their bases in the crossing solution for two weeks, after which the stalks are removed from the crossing solution and moved outside during the day until the flowers emerge.

All stalks with emerging flowers are placed in a waiting area in the heated glasshouse and are inspected three times a week for signs of opened florets. When the florets open, the flowers are inspected carefully and graded for the amount of pollen being shed. This information is recorded, the crosses are decided upon and are set up in crossing compartments. There are five groups of crossing compartments, and on any one crossing day only one group is used. The groups are numbered one to five from South to North. The flowers shedding pollen (male flowers) are placed above the seed-bearing flowers (female flowers). The male flowers are shaken daily between 08h00 and 08h30. The crosses remain in the compartments for ten days and then the female flowers are moved to a ripening area. The flowers remain there until the tassels start fluffing. The flowers are then cut from the stem and the fuzz is placed in a dehumidifier for 24 to 36 hours before being placed in a polythene bag which is sealed and placed in a deep freeze at −10°C.

Fuzz is sown annually in January in boxes containing specially prepared soil. The seed is covered lightly with peat moss and a fine spray is used to moisten the peat moss. Thereafter, the boxes are placed in a heated glasshouse and watered from a watering can. Seedling counts are made six days after sowing by counting the seedlings in ten random parts of the box. The numbers for each cross are noted and such numbers have been used for this study.

The mean number of seedlings per cross made in different compartment groups was determined for the 1973 to 1978 crossing seasons. Numbers from melting pot crosses (more than one male variety) were excluded from these means. The mean temperature and mean humidity values after setting up the crosses in the compartments were determined for each group for the following periods :

T1 — mean temperature at 06h00 for 5 days.
T2 — mean temperature at 06h00 for 3 days.
T3 — mean minimum temperature between 06h00 and 10h00 for 3 days.
H1 — mean humidity at 06h00 for 5 days.
H2 — mean humidity at 06h00 for 3 days.
H3 — mean minimum humidity between 06h00 and 10h00 for 3 days.

To determine the effect of photoperiod treatments on the numbers of seedlings obtained from crosses made in 1976, 1977 and 1978, the numbers from male and female flowers were determined separately. These numbers excluded those of melting pot crosses as well as numbers from groups of compartments that provided a mean of less than 100 seedlings per cross.

Results

The mean numbers of seedlings obtained from crosses made in 1977 varied from 55 from compartment group 1 to 234 from group 5. A mean temperature of 27,3°C was recorded for group 1 compared with 24,7°C for group 5.

TABLE 1

Coefficients of correlation between seedling numbers and mean temperature and mean humidity in 1977

Temperature/humidity	Compartment groups		
	Combined 1 and 2	Combined 4 and 5	Combined 1 and 2 and 4 and 5
T1	− 0,74**	− 0,24	− 0,57**
T2	− 0,67**	− 0,14	− 0,51**
T3	− 0,71**	− 0,08	− 0,53**
H1	− 0,08	− 0,14	− 0,07
H2	− 0,15	− 0,14	− 0,07
H3	− 0,03	− 0,13	− 0,30

** Significant at the 1% level.

The coefficient of correlation between the numbers of seedlings obtained and mean temperature values for 1977 crosses was highly significant for groups 1 and 2 (combined) and also for the combination of groups 1 and 2 (combined) and 4 and 5 (combined) as shown in Table 1. The negative values indicated that the temperatures in the glasshouse, particularly for groups 1 and 2, were too high and affected seedling numbers adversely. The values for groups 4 and 5 were also negative, but were not statistically significant. Humidity did not appear to affect seedling numbers significantly.

The numbers of seedlings obtained in all seasons from 1973 to 1978 were compared with temperature and humidity values at the time of pollen shed (Table 2). Crosses made in 1973 gave large numbers of seedlings and neither temperature nor humidity had any adverse effect on these numbers.

TABLE 2

Coefficients of correlation between seedling numbers and temperature and humidity in six seasons

Year of cross	Part of glasshouse	Coefficient of correlation between seedling numbers and		
		Temperature T1	Humidity	
			H1	H3
1973		—0,19	0,22	— 0,11
1974		—0,58**	0,24	0,45**
1975		— 0,61**	0,67**	0,33**
1976		— 0,32*	0,00	— 0,10
1977		— 0,54**	— 0,12	— 0,36*
1978		— 0,06	— 0,05	— 0,03
Combined 1974 and 1975	S + SW†	— 0,52**	0,36	0,49*
	SE + E + NE	— 0,68**	0,52**	0,22
	NE + NW	— 0,59**	0,71**	0,32
	W + SW	— 0,58**	0,61**	0,42*

* Significant at the 5% and ** 1% level, respectively.
† Part of glasshouse, S = south, SW = south west, etc.

High temperatures adversely and significantly affected the numbers of seedlings obtained in the four seasons from 1974 to 1977. The temperatures registered on several days in 1978 were well below 20°C. As a result, the numbers of seedlings obtained were reduced (Brett[2]) and there was no correlation between high temperature and low seedling numbers in this year. The numbers of seedlings obtained were apparently reduced significantly by low humidity (H1) in 1975. There was a statistically significant association between minimum humidity (H3, Table 2) and the numbers of seedlings obtained in 1974, 1975 and 1977. Combining the data for 1974 and 1975 and partitioning the glasshouse into six parts showed that high temperatures were associated with significantly reduced numbers of seedlings in all parts of the glasshouse. Low humidity (H1) also appeared to reduce the numbers of seedlings except in the southern end of the glasshouse. Minimum humidity (H3) affected the numbers of seedlings obtained significantly in two parts of the glasshouse.

The main photoperiod treatments in the photoperiod house and the glasshouse have been repeated annually, and the numbers of seedlings obtained from flowers grown in these treatments in 1976, 1977 and 1978 have been combined (Fig. 1). Flowers from treatments which led to early flowering gave fewer seedlings per cross than did flowers from treatments which led to late flowering, in both the glasshouse and the photoperiod house. Plants in treatment P_2 flowered two to three weeks later than plants in treatment P_1, and although P_2 females produced an acceptable number of seedlings, the P_2

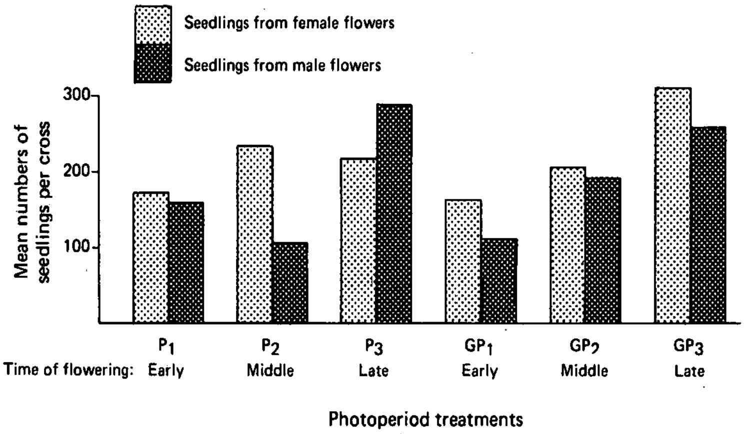

FIGURE 1 Numbers of seedlings obtained in 1976, 1977 and 1978 from flowers grown in different photoperiod treatments.

males gave few seedlings. In 1973 a mean number of 615 seedlings were obtained from female flowers in treatment P_3, compared to 214 in 1976-78 (see Figure 1). Similarly, the number of seedlings obtained in treatment GP_2 was 843 in 1973, compared with 202 in the more recent seasons.

The following observations have been made on the numbers of seedlings obtained from flowers grown in different photoperiod treatments :

1. Changing the decline in daylength from slow (or no decline) to a faster decline produced male flowers giving rise to many seedlings and female flowers giving disproportionately few seedlings.
2. Fewer seedlings were obtained from flowers grown in constant daylengths than from flowers grown in declining daylengths. Constant daylengths produced a higher proportion of male flowers and these gave fewer seedlings than flowers from declining daylengths.
3. Flowers grown in the field and cut as early boents produced large number of seedlings.
4. Numbers of seedlings obtained from melting pot crosses are still better than from biparental crosses. For example in 1976, biparental crosses gave only a third (200) of the numbers obtained from comparable melting pot crosses.

Discussion

After being marcotted all flowers received the same treatment in the glasshouse and were kept in the same areas. At the time of pollination flowers were kept in different compartments where differences in temperatures and humidity could have affected seed set and therefore the numbers of seedlings obtained. Pollen collected at 09h30 did not germinate as well as did pollen collected between 08h00 and 09h00 (unpublished data). Hence temperature and humidity were measured at 06h00, the time at which pollen shed was thought to start.

Earlier work on flowering of sugarcane had primarily been concerned with initiation, flowering and improved pollen shed under artificial conditions (Brett [2,3], Brett and Harding[4]). In this investigation the high temperatures and low humidities at the time of pollination were found to affect significantly the numbers of seedlings obtained from these crosses. Because the seed is covered with glumes and hairs, no attempt was made to determine whether seed set or the viability of the seed had been affected. The mode of action of adverse conditions of temperature and humidity is not clear. These may affect the rate of pollen shed, pollen fertility, pollen tube growth in the style, the fertility of the ovule or the growth of the fertilized ovule. Since melting pot crosses gave higher seedling numbers than biparental crosses, it is probable that high temperature accelerates pollen shed more than it increases the rate of style appearance in female flowers. A different rate of pollen shed among varieties would explain why more seedlings were obtained from melting pot crosses than from biparental crosses.

Factors other than temperature and humidity might also be involved in determining the numbers of seedlings obtained. Crosses made on days when temperatures were high did not always give low numbers of seedlings. Photoperiodism is known to affect numbers of flowers as well as fertility of florets (Evans[5], Vince-Prue[7]), sometimes by interacting with different temperature regimes. In maize, treatments favouring flower initiations and development may cause microprogenesis to be inhibited. (Vince-Prue[7]). In the local cane breeding programme a large proportion of the flowers used for crossing is obtained by artificial induction of flowering. Few direct comparisons of the numbers of seedlings obtained from flowers grown in different photoperiod treatments are possible because the flowers are used primarily for producing seedlings for the selection programme. The separate totals of all seedlings obtained from females and males of a particular photoperiod treatments showed that flowers from treatments initiated early in the season produced fewer seedlings than those from treatments initiated later. This could have been partly due to higher ambient temperatures early in the flowering season. Few seedlings were obtained from flowers exposed to a constant daylength, considerably more being obtained from flowers grown in treatments where daylength was changed from a slow decline to a fast decline. Photoperiod treatments were primarily intended to improve flower initiation and emergence and it was simply assumed that photoperiod treatments giving a large proportion of male flowers would also produce acceptable numbers of seedlings. However, there are indications, as with constant daylengths that in treatments with a high proportion of male flowers, the crosses actually produced a relatively small number of seedlings.

Cane grown in the field until the first signs of flowering appear, and then marcotted in the glasshouse, gave rise to more seedlings than did cane grown under similar photoperiod conditions but in a heated glasshouse. The latter cane was grown in sand supplemented with major nutrients. The nutritional status of the plants presumably affects eventual seedling numbers.

Several factors are probably involved in determining the numbers of seedlings obtained from a crop. High temperature and low humidity at the time of pollen shed evidently have a direct effect on numbers of seedlings obtained (Tables 2 and 3). Time of flowering in the season, photoperiod treatments and possibly nutritional status of the cane, seem to affect the numbers of seedlings indirectly, that is, through their influence on the flower before pollination takes place.

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