THE EFFECT OF *CERCOSPORA BETICOLA* (LEAF SPOT) AND DISEASE CONTROL MEASURES ON SUGAR BEET IN NATAL

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Abstract

The results of the first year of a three year feasibility study on the growing of sugar beet in Natal showed that *Cercospora beticola* is likely to be the most serious agronomic problem. In the second season of this study, the disease control measures of planting date, varietal resistance and fungicide application were investigated at two sites. The one was in the cooler (1 450 m in altitude) and the other in the warmer (950 m in altitude) region of the prospective sugar beet area.

Leaf spot infection at the low altitude site at Baynesfield was markedly greater than at Nottingham Road. This was ascribed to the longer and more frequent daily periods of high humidity and temperature at Baynesfield than at Nottingham Road, particularly in December and January.

The best drilling date was early in spring since this allowed a large proportion of the crop's growth to take place before its defoliation which occurred in February. Varieties Cremona, Kawerita and Kawecercopoly resisted infection for a while but were eventually defoliated by leaf spot in the same way as the susceptible varieties. A combination of fungicide treatment and varietal tolerance gave the highest sucrose yields (12 t/ha) at Nottingham Road. The same treatment at Baynesfield failed to control the disease which eventually resulted in total crop loss.

Introduction

Leaf spot is regarded as one of the most destructive and widespread fungus diseases affecting sugar beet. In the U.S.A it is most destructive in the central areas from Ohio and Michigan to Colorado and in the high plains area of north west Texas[2]. Sugar beet industries in Austria, Greece, Hungary, Italy, Rumania, Turkey and Yugoslavia would be severely affected by *Cercospora beticola* in most years if fungicides were not used[7].

Leaf spot was recognised as the most serious problem likely to arise in a sugar beet crop in Natal[8].

The disease requires fairly high temperatures (25°C) and hygrometrical conditions approaching saturation in order to propagate rapidly. The incubation period can be as low as 6 days in suitable conditions[5].

Wallin and Loonan (1971) kept sugar beet plants in a saturated atmosphere for 10 to 72 hours. They found that the effect of lengthening the wetness period on the number of lesions was striking. Ten days after inoculation only a few spots appeared on plants that were kept wet for 10 or 12 hours. Thirty times more lesions appeared on plants placed for 48 h in a saturated atmosphere than those receiving 24 h of this treatment. Plants that were kept wet for 48 h suffered the greatest infection when the temperature was held at 29°C during that period. Temperatures above or below 29°C resulted in less severe infection.

Relative humidity values in excess of 98% were found to be ideal for sporulation[3]. The rate of sporulation as well as the size of the spores diminished considerably as humidity fell below 80%[5].

The disease is controlled world wide mainly by fungicides whilst the use of disease resistant genotypes is less common.

The number of applications of fungicide required, varies from two in California[12] to ten in Greece in some years[1]. The sugar beet industry in Greece is highly dependent on fungicides and the entire crop receives several applications each season[7].

Until 1968, triphenyl-tin derivatives were the most effective fungicides used in Greece but these did not control the disease in some years. Various systemic fungicides were tested and benomyl was consequently used in the national spraying programme[6]. Benomyl has been shown to be one of the most effective fungicides for controlling *Cercospora beticola* in other countries as well [9, 14, 10]. Solel[13] found that benomyl moved from treated petioles into non-treated blades of sugar beet leaves and he[15] later found this chemical to be highly active against germinating spores 11 days after application. The activity of fentin acetate, TBZ and thiophanate declined more rapidly.

Varieties with some measure of disease resistance have been available since 1938 but are seldom sufficiently resistant not to require chemical protection[2]. Resistant varieties are used in Greece only to augment the fungicides in areas where conditions are most suited to leaf spot. Susceptible varietes are planted in most areas since these give higher yields than resistant varieties when both are sprayed[1].

Crane and Calpouzos[4] showed a decline in the rate of leaf senescence when fungicide was applied to a susceptible variety. Leaf death rate was lower in a resistant variety and lower again when fungicide was applied to this variety. Undiseased leaves could remain alive for 13 weeks whereas diseased leaves lasted only 1 to 5 weeks. Mature, healthy plants had 28 to 32 green leaves each while diseased plants had about 15 leaves each.

The inherent disease resistance of immature leaves has been known for a long time[11]. It is conceivable that this phenomenon could be exploited by drilling at a time that will ensure that leaves are immature during the period when the greatest infection is expected.

Experiments were conducted during the 1976/77 season in Natal to evaluate three possible ways of overcoming the leaf spot problem. These are a) planting date b) varieties with a greater measure of resistance than others and c) fungicides.

Methods

Three types of field experiment were conducted to investigate each one of the aforementioned factors but not the exclusion of the other two factors (Table 1).

TABLE 1

Factors in sugar beet experiments conducted to investigate control measures for leaf spot.

Site	Main variable	No. of levels of		
		Drill date	Variety	Spraying
Meyershoek	Planting date*	4	2	3
Lintrose	Planting date*	4	2	3
Meyershoek	Variety	1	9	2
Lintrose	Variety	2	6/8	2
Meyershoek	Spraying regime	1	2	10
Lintrose	Spraying regime	1	2	10

*On each planting occasion, a separate block of land was used and these blocks were regarded as separate experiments for statistical purposes.

The two experimental sites were chosen to represent the cooler and warmer extremes of the climate under which sugar beet is possibly to be grown in Natal. The cooler site at Nottingham Road was on the farm Lintrose at an altitude of 1 450 m and the other site was at Baynesfield on the farm Meyershoek at an altitude of 950 m above sea level. Lintrose is in the highland montane bioclimatic region and Meyershoek in the coastal hinterland region. Both sites are on acid apedal clay soils of the Hutton form which comprises the deep red soils of Southern Africa.

Lime at 12 and 5 tons/ha was broadcast, incorporated and ploughed down to target depths of 45 and 30 cm at Lintrose and Meyershoek respectively. This raised the pH to 5,5 and eliminated exchangeable aluminium in the soil. Ammoniated superphosphate (8,1% P, 2,5% N) at 1 500 kg/ha was worked into the soil before planting and 300 kg/ha of KC1 and 50 kg/ha of urea were applied shortly after planting.

Weeds were partially controlled by a mixture of Roneet (cycloate) and Venzar (lenacil) which was worked into the soil before planting. These chemicals had a detrimental effect on germination in several trials.

Benlate at 500 g/ha was sprayed with a motorized mistblower which delivered 350 ℓ of the fungicide suspension per hectare. Spraying started shortly before the leaves met in the rows and usually before any lesions were present. The earliest plantings were sprayed from late November to March or April depending on the treatment. Apart from the spraying experiments where the spray interval was varied, spraying was scheduled every two weeks regardless of weather conditions.

Roots were lifted from mid-June to mid-July except where rotting occurred as a result of severe leaf spot infection. The variety trial and spraying trial at Meyershoek were harvested in April and May respectively to avoid the root rot problem.

In trials where the stand was patchy as a result of herbicide damage, sections of the plots in which the plant population exceeded 60 000 plants/ha were selected for harvest.

Results and Discussion

Disease conditions

It was assumed that the climatic conditions which materially affect the time and severity of disease infection could be summarized in terms of temperature and humidity. Two-hourly temperature and relative humidity values were tabulated from charts from thermohygrographs installed in Stevenson screens at the two sites.

When the relative humidity in the Stevenson screen exceeded 90%, the microclimate in the crop was considered to be nearly saturated and therefore ideal for the processes of infection[17].

The daily duration of these conditions meaned over five day periods, at two temperature classes, is given in Table 2.

At both sites, February appeared to be the month during which conditions for the disease were most favourable. The build up to these conditions started earlier at Meyershoek than at Lintrose. There were extended periods of high temperature and high humidity during December at Meyershoek but not at Lintrose. These conditions became more prevalent during January at Meyershoek and also at Lintrose but to a smaller extent. There was a rapid decrease in the occurrence of high temperature and humidity combinations during March at both sites. Long periods of saturated atmospheric conditions persisted till the end of April at Lintrose and through May at Meyershoek but the corresponding temperature values declined steadily.

Although lesions appeared in mid-January at both sites, it is considered that the occurrence of high humidities with high temperatures early in the season at Baynesfield was responsible for the outbreak of leaf spot being more serious there than at Nottingham Road.

Disease effects in general

Leaf canopy: Leaf spot rapidly reduced the size of the leaf canopy. Figure 1 shows this effect on a susceptible and on a resistant variety planted at various stages from September to January at Lintrose. The later plantings were clearly less affected by the disease than the earlier plantings. In the worst disease situation (early planted Nomo without fungicide treatment), the percentage of soil covered by leaves dropped to 40% in April. There was a general recovery in the leaf canopy of badly affected plots after April at Lintrose.

Defoliation of the crop by leaf spot was delayed and reduced by planting later, by using disease resistant varieties and by spraying fungicides. The effects of these factors were, to some extent, additive. Some defoliation could be ascribed to the drying out of soils in May and June.

At Meyershoek, the rate of defoliation by leaf spot was much higher than at Lintrose. The percentage of ground covered by the leaf canopy fell from 100 to 25% within six weeks in some plots at Meyershoek whereas at Lintrose the plots with the highest disease rating lost only 35% of their leaf cover during the same period. There was little sign of a recovery in the leaf canopy at Meyershoek.

Leaf numbers: Seven trials were selected for a study of the effects of leaf spot on leaf numbers. Four plants in each plot were tagged and the number of green leaves were counted on several occasions. The number of new leaves produced in the interval between counts was determined by ringing the youngest expanded leaf. Over 1 000 plants were monitored in this way.

As many as 36 green leaves were recorded on healthy plants. Badly diseased plants at Meyershoek remained alive for a while with only one or two green leaves whereas the most diseased plants at Lintrose seldom had less than 13 healthy leaves.

Figure 2 shows how the number of leaves changed throughout the season in a good and a bad disease situation at Lintrose. The numbers changed as a result of varying death rates rather than production rates. The rate of leaf production was, if anything, increased by the disease. In many cases a significant negative correlation existed between the number of leaves and the rate of leaf appearance. Death rates tended to

TABLE 2

Mean daily duration (in hours) of saturated atmospheric conditions (R.H.>90%) for pentades at two sites in Natal)

Pentade ending on	Nottingham Road 10-15°C,	Nottingham Road 15-21°C	Baynesfield 10-15°C,	Baynesfield 15-21°C
Dec 13	3	2	0	6
18	7	2	2	8
23	3	3	4	12
28	4	2	0	9
Jan 2	6	3	3	4
7	0	9	0	16
12	0	9	0	6
17	3	5	0	10
22	3	6	0	12
27	4	7	4	6
Feb 1	0	13	0	12
6	0	13	0	10
11	0	12	0	9
16	2	10	0	11
21	0	10	0	12
26	0	9	0	10
Mar 3	8	0	4	4
8	6	10	0	13
13	10	2	4	0
18	11	2	2	0
23	13	0	10	4
28	11	2	3	2
Apr 2	8	6	4	5
7	11	3	8	0
12	10	2	11	2
17	6	0	6	0
22	2	0	6	2
27	3	0	6	2

peak early in the disease period in unprotected susceptible varieties and later in the season in sprayed and/or resistant varieties.

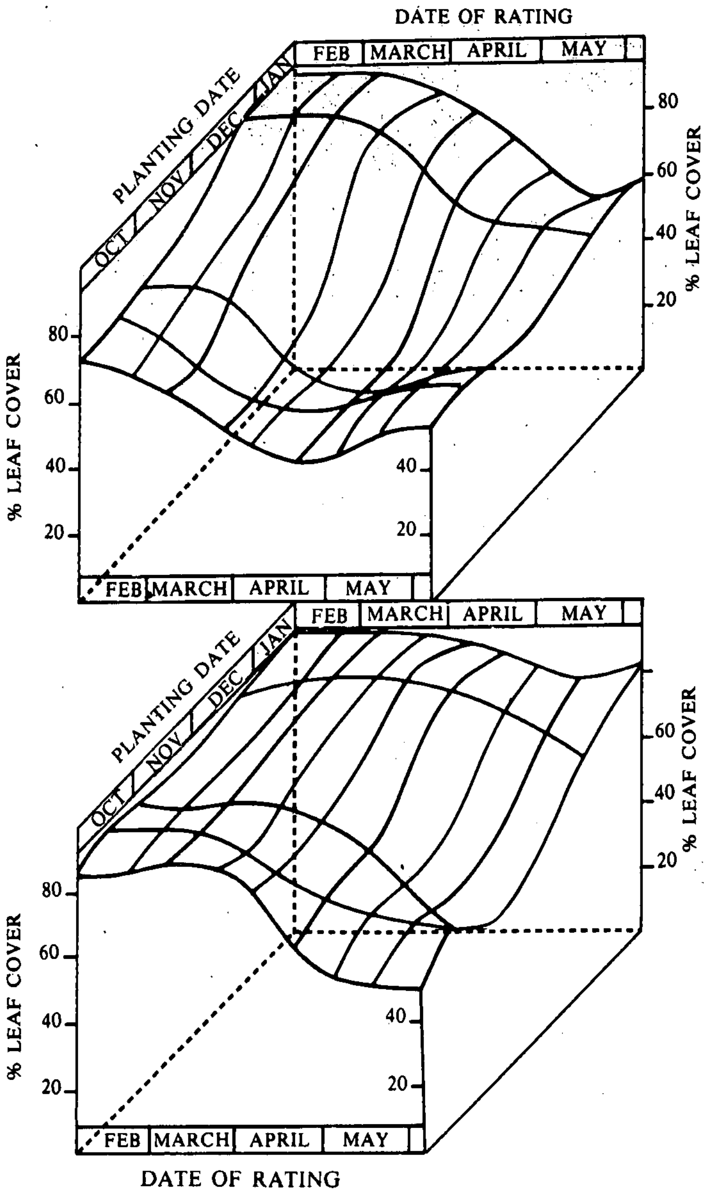

Figure 1: Seasonal changes in leaf canopy of sugar beet planted at 5 stages. Unsprayed Nomo (top), Sprayed Cremona (bottom).

Effect of planting date

At Meyershoek, the effect of leaf spot on yield decreased as planting date was delayed. The first two plantings were weakened so much by leaf spot that roots were decomposed in the ground largely by *Sclerotium rolfsii.*

The effect of planting date on mean root and sucrose yields and the yield parameters of sprayed Cremona relative to those of unsprayed Nomo at Lintrose, is shown in Figure 3. The combination of disease resistance and fungicide had its greatest effect on yield parameters in the late October planting. This result confirms the previous observation[8] that the yields of crops planted in late October to November are affected more by leaf spot than those of earlier or later plantings. The earlier plantings have a considerably longer disease free period in which to develop and the later plantings are less mature and therefore more resistant to leaf spot during the peak period of its activity in February and March.

Root and sucrose yields declined linearly (r = 0,96 and r = -0,98 respectively) with the delay in drilling. An average of 600 kg/ha of root yield and 93 kg/ha of sucrose yield were lost for each day's delay in drilling.

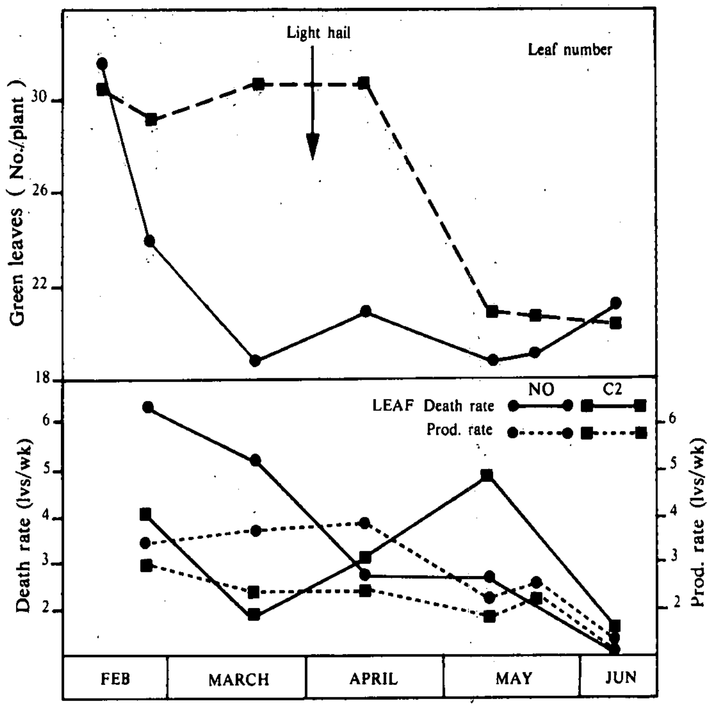

Figure 2: Seasonal changes in the number of green leaves, rate of leaf production and death rate of leaves on plants of unsprayed Nomo (NO) and sprayed Cremona (C2) at Lintrose.

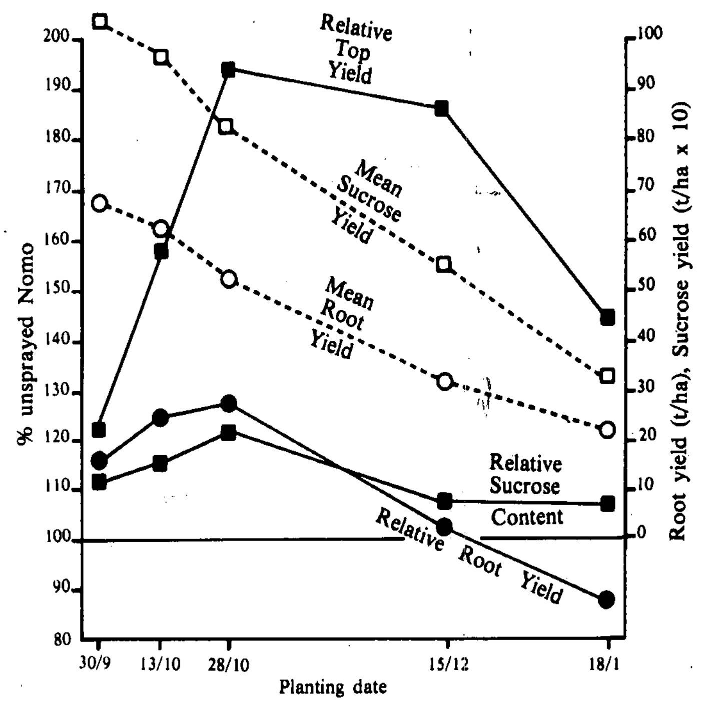

Figure 3: Yield of sprayed Cremona relative to unsprayed Nomo (solid lines) and mean yield of all treatments (broken lines) as influenced by planting date.

Fungicide spraying and varieties

Disease resistance was investigated largely by comparing Nomo with Cremona. The comparison of seven other varieties served to confirm the results obtained from this comparison.

Nomo represented the susceptible varieties and Cremona the varieties with a measure of disease resistance.

The interaction between varietal resistance and fungicide was clearly demonstrated by the results of the December planting at Meyershoek (Fig. 4).

Disease control and yield improved according to the following order of treatments:

1. Nomo unsprayed

2. Nomo sprayed during March
3. Nomo sprayed during March and April
4. Cremona unsprayed
5. Cremona sprayed during March
6. Cremona sprayed during March and April.

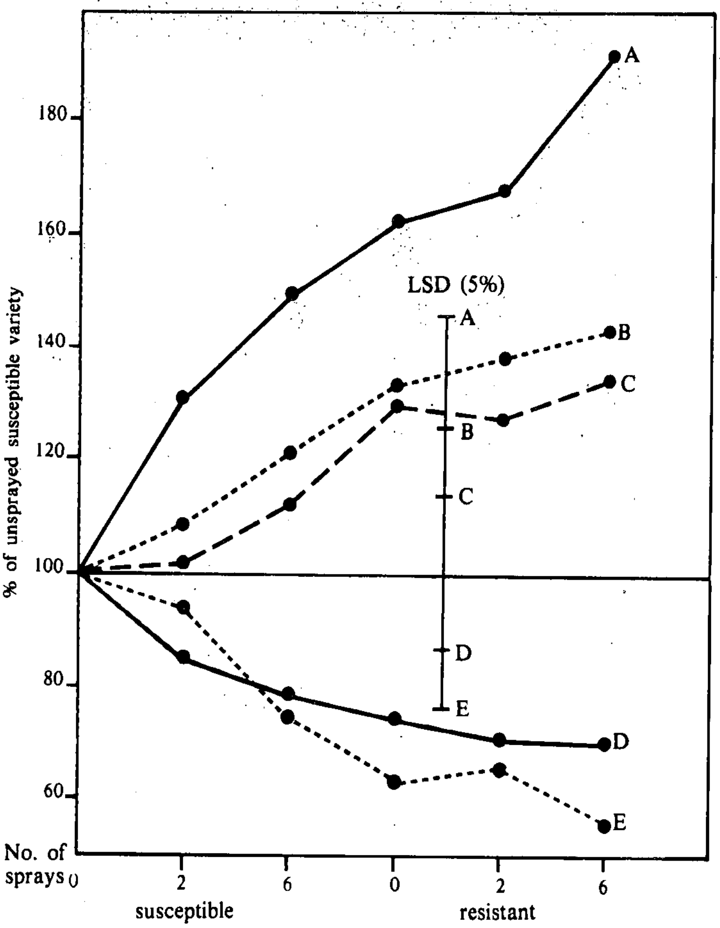

Figure 4: Effect of fungicide and disease resistance on A) root yield B) number of green leaves C) sucrose content D) relative rate of leaf appearance E) leaf death rate, expressed as a percentage of values for unsprayed Nomo.

The sucrose yield of Cremona given full protection was 2,29 t/ha and that of Nomo given no protection was 1,26 t/ha. Leaf spot lesions did not appear on this crop until early March. Conditions for leaf spot, thereafter, were still favourable judging by the damage done to unprotected, susceptible plants.

It is interesting to note from Figure 4 that the increase in leaf numbers was due to the death rate decreasing more rapidly than the leaf appearance rate, as disease control improved.

The above ranking of treatments applied to sucrose content, leaf cover, leaf production rate, leaf death rate and top yield in most trials where these treatments occurred. The root yield of Cremona relative to that of Nomo declined as drilling was delayed (Table 3) thus indicating that root growth rate of Cremona was inherently lower than that of Nomo. Previous work on sugar beet in Natal[8] showed that root mass increases asymptotically and that near-maximum mass may be reached as early as March. It is conceivable then that root yields of Nomo and Cremona drilled in September and October were similar because the growth season was long enough to allow both varieties to reach maximum root size or because the disease resistance of Cremona compensated for its lack of vigour or because of a combination of both reasons.

Cremona roots had a consistantly higher (10%) sucrose content than did Nomo and this gave it a distinct advantage over Nomo in sucrose yield in the early drillings. Cremona also compared favourably with eight other varieties that were tested. Two of these, Kawerita and Kawecercopoly were regarded as resistant varieties. The others were not expected to have any particular resistance to *Cercospora leticola*.

TABLE 3

Root and sucrose yields of a susceptible (Nomo) and a resistant (Cremona) variety of sugar beet planted at five stages at Nottingham Road and harvested in July

Planting date		30/9	13/10	28/10	15/12	18/1	30/9	13/10	28/10	15/12	18/1
Variety	Spraying duration	Root yield (t/ha)					Sucrose yield (t/ha)				
Nomo	none	66	53	41	31	21	9,5	7,4	5,8	5,4	2,9
Nomo	March	59	63	58	36	25	8,9	9,9	8,6	6,2	3,7
Nomo	April	73	66	55	34	32	10,8	10,0	8,3	6,0	4,6
Cremona	none	52	61	46	25	19	8,0	9,5	7,5	4,2	3,0
Cremona	March	79	68	59	30	20	12,6	11,2	10,0	5,7	3,1
Cremona	April	74	65	56	34	17	12,4	10,6	8,8	6,4	2,4
(LSD 5%)		20	12	21		11	3,1	2,7	3,7		1,8

*Spraying started shortly after leaves met in rows and continued till March or April.

The resistant varieties sustained a larger leaf canopy and developed a higher sucrose concentration in the roots than the susceptible varieties. These two parameters were, in fact, significantly correlated ($r = 0,61$ at Lintrose and $r = 0,78$ at Baynesfield). A 1,0% difference in the sucrose content at the time of harvest was associated with a 10% difference in leaf cover at the time when treatment differences were greatest.

Root yield between varieties did not differ significantly. The highest sucrose content was found in Cremona at both sites and in both spraying treatments (Table 4). At Lintrose, the other resistant varieties also produced more sucrose than the susceptible varieties, but only where no fungicide was applied.

TABLE 4

Sucrose yield of varieties of sugar beet drilled in October at two sites

	Sucrose yield (t/ha) (unsprayed)		% Change due to spraying	
Variety	Lintrose	Meyershoek	Lintrose	Meyershoek
Kawerita	8,6	4,4	- 10	0
Kawecercopoly	7.8	3,8	+ 28	+ 23
Cremona	9,2	5,1	+ 26	+ 39
Kawegigamono	7,0	4,6	+ 21	+ 59
Kawemegapoly	–	4,5	–	+ 20
Monofort	–	5,0	–	+ 32
Salohill	–	4,1	–	0
Bush Mono G	6,4	4,0	+ 28	+ 37
Nomo	7,3	3,4	+ 8	+ 68

Spraying generally had a larger effect on root yield than varietal resistance. The mean response to spraying and to varietal resistance in the October plantings at Lintrose was 21% and 5% respecitvely. The sucrose content of all varieties except Kawerita and Salohill was increased as a result of spraying with benomyl. This increase was greater at Meyershoek than at Lintrose as could be expected.

Conclusions

The experiments on sugar beet in the 1976/77 season confirmed the expectation that *Cercospora beticola* is likely to be one of the most serious problems encountered in growing the crop in Natal. Indications are, however, that satisfactory control can be achieved in the Nottingham Road area using resistant varieties and fungicides. The so-called resistant varieties will delay infection for a few weeks longer than in the case of susceptible varieties but this resistance will eventually break down.

Unlike many countries where leaf spot is a problem, it appears that in Natal resistant genotypes would yield better than susceptible types when both receive fungicide treatment. This is probably because the growing season in Natal is longer than in most sugar beet areas and this allows the less vigorous, resistant plants enough time to reach full root size. Plants germinating early in October can develop a maximum root size by March or April thus affording 3 to 5 months of continued sucrose accumulation. The effect of varietal differences in growth rate would be eliminated in this period.

The disease problem in the Coastal hinterland areas (below 1000 m) will be far more difficult to control. It is unlikely that sufficient genetic resistance could be found at present and the solution probably lies in the direction of a fungicide spraying schedule which is governed by weather and not by the calendar alone. This may require more than 10 applications of fungicide between December and April.

Other fungicides should be tested, not least because benomyl-resistant strains of *Cercospora beticola* can be expected in the near future.

Planting date is an important factor in the disease control programme but hopes that a late planting could be used to exploit the inherent disease resistance of immature plants must be ruled out. Yield losses incurred by delayed drilling could amount to 100 kg of sucrose per hectare per day. It would appear that drilling as early as possible in spring would offer the crop the longest possible disease free period as well as the longest overall growth season for sucrose accumulation.

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