EFFECT OF SOWING DATE ON THE YIELD AND SUGAR CONTENT OF SUGAR BEET AND FODDER BEET AT FOUR SITES

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ABSTRACT

Fodder beet and sugar beet were sown on 4 to 6 dates between late August and mid December 1980 at 4 sites in Canterbury. On 2 irrigated sites, sugar yields were 15 to 17 t/ha for late August and early September sowings, thereafter sugar yields declined at a rate of over 100 kg/ha for each day sowing was delayed. On non-irrigated sites, sugar yields for equivalent early September sowings were 45% lower than for irrigated sites but declined more slowly with later sowing to become equal to irrigated sites from late November. Sowing date had little effect on root sugar content. There was little difference in sugar yield between sugar beet and fodder beet because, despite the fodder beet yielding 35% more root fresh weight, its sugar content was 27% lower.

INTRODUCTION

Roots of sugar beet and fodder beet contain up to 20% of sugar (Martin, 1980) which can be fermented to produce ethanol. Economic studies (NZERDC, 1979) indicated potential for beet crops as a feedstock for the production of ethanol for use as a liquid transport fuel in New Zealand. As these studies were based on limited yield data, the Ministry of Agriculture and Fisheries has been carrying out a research programme to identify more clearly the sugar yield potential of beet in Canterbury (sugar yield being calculated from root fresh weight yields and sugar content). Information on cultivar and time of harvest effects have already been published (Drewitt, 1979; Martin, 1980; 1981). In this study the effect of time of sowing is examined.

Data presented by Drewitt (1976) indicate that, in mid Canterbury, sugar yields from sugar beet fell from 17 t/ha in early September to 6 t/ha in mid November. Greenwood (1980) reported similar large losses from delayed sowings in Otago. In Tasmania, yields decreased when sowings were delayed after early August in an early district and after early October in a late district (Department of Agriculture, 1979). Decline in sugar beet yields with delayed sowing also occur in Britain (Hull and Webb, 1970).

Delay in drilling large areas of beet could occur if there was poor weather in early spring or if the industry was heavily dependent on contractors for precision drilling. If delayed plantings have a considerable effect on sugar yield, this could be important in planning areas of beet to be planted and for predicting yields at the end of the season.

MATERIALS AND METHODS

The crop was sown at 4 research stations with contrasting cropping soil types which could be used to grow beet if a beet industry were established. These were Adair Research Station (Claremont silt loam), Lincoln College Research Farm (Temuka silt loam), Templeton Research Station (Templeton silt loam) and Winchmore Irrigation Research Station (Lismore silt loam).

All sites had a pre-planting basal fertilizer dressing of 30 kgK/ha, 20 kgP/ha, 0.75 kgB/ha and 120 kgNa/ha. Nitrogen (70 kg/ha) was applied 2-3 weeks before each sowing. Pelleted seed of sugar beet cv. Monoire and fodder beet cv. Monoblanc were sown at 25 mm depth using a Stanhay drill in 475 mm rows at 125 mm spacing (168,000 seeds/ha). One kg/ha phorate, mixed with 19 kg K, was placed alongside the row at drilling. Sowings were made at 3-4 week intervals from late August at Templeton and Winchmore and from early September at Adair and Lincoln. The last sowing was made in late November at Adair and in mid December at the other sites.

A split plot experimental design was used with sowing dates as main plots and cultivars as sub plots. Main plot size was 20 to 35 m long by 5 rows wide.

Metamitron (6 *l*/ha) was applied pre emergence at all sites. Split applications of 3 *l*/ha phenmidipham + desmidipham were made post emergence at Templeton and Winchmore, and single applications of 3 or 6 *l*/ha of the same herbicide were made at Adair and Lincoln. Glyphosate was used to control docks at Adair and 3,6-dichloropicolinic acid was applied at Templeton to control thistles. All crops received additional hand weeding as required. The first four sowing dates at both Templeton and Winchmore were sprayed in early November with fenitrothion to control cutworms.

Flood irrigation was applied at Templeton and Winchmore whenever the gravimetric soil moisture content in the top 0-150 mm fell to approximately 15% (25% available soil moisture). The Adair and Lincoln crops were not irrigated.

Harvesting started on 25 May at Templeton, 9 June at Winchmore, 29 June at Lincoln and 2 July at Adair. The harvest area was 8 m x 1.425 m (3 rows). Plants were hand lifted, counted, topped to remove all green material and weighed. A sample of 6 roots was washed and re-weighed to correct for soil contamination. These 6 beets were then quartered longitudinally, 52 g of gratings taken from the cut surfaces, and total sugars measured using the automated colormetric method of Quin *et al.* (1980).

TABLE 1: Rainfall data (mm) for the 4 sites from August 1980 to June 1981 with long term average rainfall for Lincoln.

	Adair	Lincoln	Templeton	Winchmore	Lincoln long-term average
Aug - Oct	48	62	52	102	150
Nov	75	85	91	113	53
Dec - Feb	86	66	102	106	170
Mar - Jun	233	194	163	193	256

RESULTS

Rainfall and Irrigation

Rainfall data is given in Table 1. Long term averages are similar for all sites. Excluding above average rainfall in November, the period from August to February generally had less than half the average rainfall.

At Templeton, irrigation started in early November for the early sowings and continued through to the end of March, the early sowings receiving 5 irrigations. On the lighter soil at Winchmore, irrigations started around the end of December but were applied more frequently, seven being applied by early April to the first two sowings.

Plant Population

Late October and November sowings at Adair and Lincoln had better establishment than September and early October sowings (Table 2). At Templeton, October sowings established better than August or September sowings. At the three sites where mid December sowings were made, establishment was poor for this late sowing, especially at Templeton.

There was a significantly higher plant population of sugar beet than fodder beet at all sites and at all sowing dates due either to poorer germination of the fodder beet, or to higher numbers of the sugar beet seed being planted

TABLE 2: Plant Populations ('000/ha) at each site.

Sowing Date	Adair	Lincoln	Templeton	Winchmore
Late August	—	—	83	100
Early September	100	77	96	119
Late September/ Early Oct	97	99	107	108
Late October	116	114	108	108
Late November	110	114	100	101
Mid December	—	64	43	77
L.S.D. (5%)	15	11	9	24
'Monoire' Sugar Beet	121	108	99	119
'Monoblanc' Fodder Beet	90	77	80	84
L.S.D. (5%)	29	11	8	9

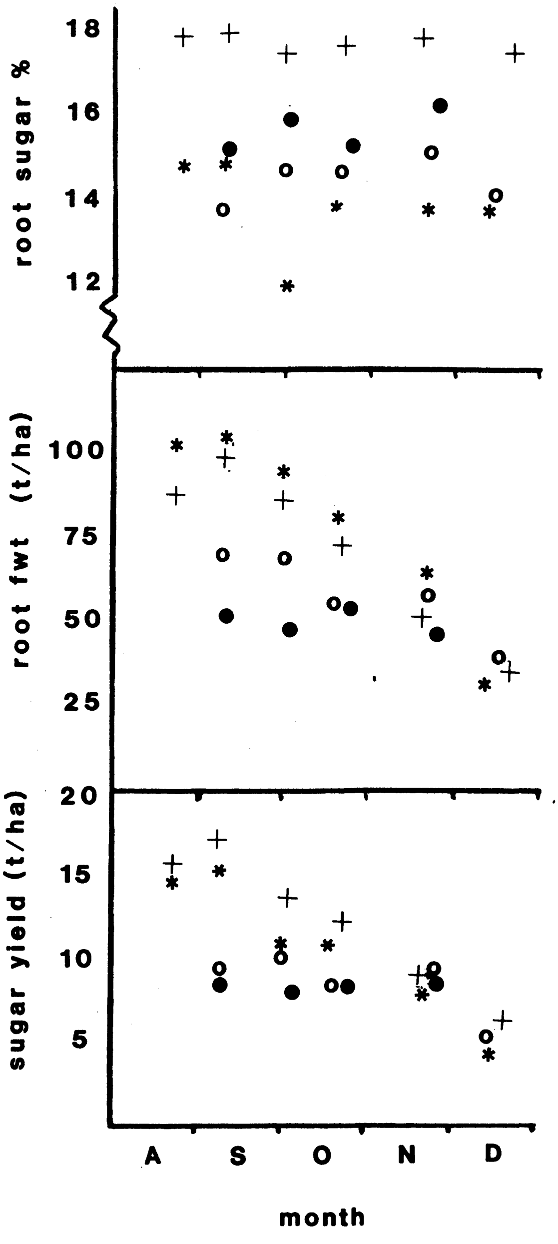

Figure 1: Root total sugar percentage, root fresh weight and root total sugar yield from different sowing dates at Adair (●), Lincoln (O), Templeton (*) and Winchmore (+). Vertical bars give L.S.D. (5%) for horizontally adjacent symbols.

TABLE 3: **Mean sugar content and root and sugar yields of 'Monoire' sugar beet and 'Monoblanc' fodder beet for all sowing dates at the 4 sites.**

	Adair	Lincoln	Templeton	Winchmore
Root total sugar content (% fresh weight)				
'Monoire' Sugar Beet	18.4	16.8	16.4	20.0
'Monoblanc' Fodder Beet	13.4	12.3	11.4	15.6
L.S.D. (5%)	1.0	0.7	1.3	0.3
Significant Interactions	—	—	—	Sowing Date (lin) x Cultivar (5%)
Root fresh weight (t/ha)				
'Monoire' Sugar Beet	47.1	48.7	66.2	60.2
'Monoblanc' Fodder Beet	54.4	69.8	94.6	83.2
L.S.D. (5%)	2.0	3.5	3.5	3.6
Significant Interactions	—	—	Sowing Date (quad) x Cultivar (5%)	—
Root total sugar yield (t/ha)				
'Monoire' Sugar Beet	8.7	8.2	10.9	12.0
'Monoblanc' Fodder Beet	7.8	8.7	10.6	12.5
L.S.D. (5%)	0.4	0.5	1.0	0.8
Significant Interactions	Sowing Date (quad) x Cultivar (1%)	Sowing Date (lin) x Cultivar (1%)	—	—

because of deterioration of seed pellets during storage. To correct for this difference in plant population, covariate analysis was carried out for root fresh weight and sugar yield. The fodder beet data was then adjusted to the same population as the sugar beet within each replicate and sowing date before the analyses of variance were carried out.

Sowing Date

The effect of sowing date on root fresh weight, root total sugar content and sugar yield is shown in Fig. 1 and the effect of cultivar and the occurrence of sowing date — cultivar interactions in Table 3.

Sowing date had no effect on root total sugar content at Adair and Templeton although sugar percentages at Templeton were inexplicably low for the late September sowing (Fig. 1). Sugar percentages were significantly lower at the first and last sowings at Lincoln. At Winchmore, the sowing date x cultivar interaction was due to sugar beet sugar percentages declining slightly with later sowings whereas fodder beet sugar percentages fluctuated. Sugar contents varied markedly between sites being nearly 18% at Winchmore but only 14% at Templeton.

Root and sugar fresh weights at Winchmore increased significantly from mid August to early September but not at Templeton (Fig. 1). Thereafter, yields at these two irrigated sites declined steadily from an average of just over 100 t/ha of roots and over 16 t/ha of sugar in early September to less than 40 t/ha of roots and under 6 t/ha of sugar in mid December. At Templeton the sowing date x cultivar interaction (Table 3) was due to root weights of fodder beet declining more rapidly with delayed sowing than sugar beet.

Compared to the irrigated sites, root and sugar yields on the dryland sites were considerably lower in September, sugar yields being under 10 t/ha at Lincoln and 8 t/ha at Adair (Fig. 1). Yields declined more gradually at Lincoln compared to the irrigated sites and changed little at Adair. By late November there was little difference in root and sugar yields at all sites. The sowing date x cultivar interaction at Adair was due to sugar beet sugar yield being unaffected by sowing date, whereas fodder beet had a significantly lower sugar yield at the early October sowing. At Lincoln, the interaction was due to sugar beet sugar yields decreasing with delayed sowing dates whereas fodder beet yields fluctuated.

Effect of Cultivar

Covariance adjusted mean root fresh weights of fodder beet at Adair were 7.3 t/ha higher than sugar beet but over 20 t/ha higher at the other sites (Table 3). However, sugar percentages of fodder beet were on average 4.5% lower. This resulted in sugar beet having a significantly higher sugar yield at Adair but there was no significant difference in sugar yield between sugar beet and fodder beet at the other sites.

DISCUSSION

At the two irrigated sites, sugar yields decreased from over 16 t/ha in September to under 6 t/ha in December. This decrease represented an average yield loss of over 100 kg of root total sugar per hectare per day, equivalent to 55 *l*/ha of anhydrous ethanol. A similar rate of yield loss due to delayed sowing has occurred in Tasmania (Department of Agriculture, 1979). In a previous trial at Winchmore reported by Drewitt (1976), June sugar yields fell from 17.1 tonnes/ha for the early September sowing to 6.3 t/ha for the mid November sowing representing a yield loss of 140 kg sugar per hectare for each day's delay in sowing.

The failure of the August sowings to outyield the September sowings at Templeton and Winchmore could be partly due to the low rainfall over the spring (13.2 mm at Templeton from 16 August to 15 October) which, coupled with shallow sowing (25 mm) in a fluffy seedbed, slowed germination and emergence. Wofford and Dexter (1955) showed that beet seedling emergence was reduced if seedbeds were loose and dry. At most sites a second emergence of seedlings occurred in the early sowings after the light rain in mid October. However, these results are in line with those of Drewitt (1976) who also found that yields did not decrease from a late August sowing to a mid September sowing.

Plant populations for the December sowing, particularly at Templeton, were sufficiently below the optimum of 70,000 - 100,000 plants/hectare reported from overseas (e.g. Draycott and Webb, 1971; Storey and Barry, 1979) to have caused reduced beet yields. Reasons for the reduced plant stand are unknown, although establishment of late-sown beet crops in Britain can be greatly reduced by the soil-borne fungus *Aphanomyces cochliodies* (Byford and Stamps, 1975) which is active when soil temperatures are high. Even with a high establishment however, it is unlikely that yields would have been greatly increased as similar declining trends with later sowing have been reported previously (Drewitt, 1976; Department of Agriculture, 1979).

Data from this and other trials (Drewitt, 1976; Department of Agriculture, 1979) indicate that beet should be sown in September to ensure that high yields are obtained under irrigated conditions. This may require that primary cultivation and basal fertilizer applications be carried out in the autumn, as recommended in Britain (SBREC, 1980). If this means that farmers lose the use of land for winter grazing of pasture or greenfeed prior to beet sowing then returns to the farmer may need to take account of this loss.

The low spring rainfall may also explain the lack of response to sowing date at Adair although this may have been aided by a heavy infestation of docks in the earlier sowings and the much smaller response to sowing date on a deep soil at Lincoln compared with the irrigated sites. Previous trials at Winchmore (Drewitt, 1976) have shown large responses of sugar beet to irrigation and although this dry spring was unusual for Canterbury, these results indicate that, for high yields, provision for irrigation is desirable. However, November and December sown crops in the non-irrigated sites yielded as well as those which received 2-5 irrigations after Christmas on the irrigated sites. This suggests that, despite the dry summer, these later sown non-irrigated crops had sufficient water for establishment and growth particularly after the rain in November. However, it should be noted that the irrigated sites were harvested up to a month earlier than the non-irrigated sites. In a previous trial, Martin (1981) found that sugar yields increased over June by about 1 tonne/hectare. If harvest date is taken into account then yields from the irrigated sites would be proportionately higher compared to the non-irrigated sites.

Root and sugar yield data have been presented with fodder beet plant populations adjusted up to those of sugar beet. It could be argued that this adjustment was unnecessary as Storey and Barry (1979) have shown no increase in root yield from fodder beet as plant populations increased from 52,000 to 120,000 plants per hectare. Similarly, for sugar beet, there seems to be no increase in yield with plant populations over 80,000 plants per hectare (Draycott and Webb, 1971). Without this adjustment the sugar yield of the sugar beet would on average have been 12% higher than the fodder beet, although the adjustment varied considerably between site and sowing date.

Even when adjusted for plant population, overall sugar yields from fodder beet were no higher than from sugar beet. This confirms previous results where high yielding sugar beets have been compared with fodder beet (Drewitt, 1979; Martin, 1980). The higher concentrations of sugar in the sugar beet will make it the preferred beet due to lower transport and handling costs per tonne of sugar.

Although this paper only gives data from a single season, yields closely correspond to those of Drewitt (1976; 1979) and Martin (1980; 1981) when sowing date is taken into account. Average commercial paddock yields may be considerably lower than these small plot experimental yields due to wasted headland areas, mechanical harvesting losses and less precise management on the paddock scale (Palmer, 1981).

CONCLUSIONS

1. Within each site, yields varied little between crops sown in late August and early September.
2. For sowings after early September, sugar yields declined by over 100 kg/ha/day for each day's delay in sowing from high yielding sites. Where yields of early sown crops were restricted, e.g. by lack of water or weeds, the yield reduction was less with delayed sowing.
3. In a season with a very dry spring, irrigated sites gave much higher yields than unirrigated sites but the difference decreased with delayed sowing.
4. Sowing date affected root yield but not sugar percentage.
5. There was no significant difference in sugar yield between sugar beet and fodder beet.

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