EFFECT OF SOWING DATE, PLANT POPULATION AND PLANTING METHOD ON THE GROWTH AND DRY MATTER YIELD OF SUGAR BEET

Abid Hussain & R.J. Field*
Department of Agronomy,
University of Agriculture, Faisalabad
**Department of Plant Science,*
Lincoln College, New Zealand

Effects of sowing date, plant population and planting method on the accumulation of leaf area index and dry matter yields in sugar beet *(Beta vulgaris* L., cv. Amazon) were investigated during 1982/83 season at Lincoln College, New Zealand. Both the mid-August sowing and the transplanted beet had higher leaf area index than that of the mid-September sowing and the seed-sown beet, respectively, only until January harvest. A population of 10 plants m^{-2} had a significantly higher leaf area index than a population of 6 plants m^{-2} throughout the growing season.

Total dry matter or root dry matter yields of the mid-August sowing or the transplanted beet were significantly greater than those for the mid-September sowing or the seed-sown beet, respectively. A population of 10 plants m^{-2} produced higher dry matter yields than a population of 6 plants m^{-2}. Final root DM yield was 19.3% greater at the higher density.

INTRODUCTION

Empirical research indicates that sugar beet responds positively to the extension of the growing season, and this usually leads to the increased yield (Martin, 1983). However, even early-sown crops fail to intercept about 40% of the radiation incident over the whole season (Scott *et al.,* 1973). This coupled with the inability of the seed to germinate at low temperatures, tends to limit what can probably be achieved by still earlier sowings. Transplanted breed may be established earlier to extend the growing season. Because of the limited research information available, it was desirable to investigate how early transplanted beet can be established for successful yields.

Plant population influences plant size, root weight and sugar content (Hussain, 1990). Experiments on the effect of plant population on sugar beet production indicated that, in different environments, populations between 75,000 to 100,000 plants ha^{-1} gave optimum yields (Hull and Jaggard, 1971). In the United Kingdom, Wickens (1982) studied a range of populations (45,000-70,000 plants ha^{-1}) in both seed-sown and transplanted beet and reported little differences in yield between the plant populations, irrespective of the planting method. In New Zealand, no research work has been reported on the growth and dry matter yields of the transplanted beet. Therefore, the objective of this study was to examine the effects of sowing date, plant population and planting method on the leaf growth and dry matter yields in sugar beet.

MATERIALS AND METHODS

The experiment was conducted in the 1982-83 season at the Lincoln College Research Area, New Zealand. The fertilisers

(100, 24 and 68 kg ha^{-1} of NPK) were broadcasted as a mixture before final cultivation.

The treatments were two sowing dates (mid-August, mid-September), two plant populations (6 plants and 10 plants m^{-2}) and 3 planting methods (seed-sown, 2-leaf and 4-leaf transplants). The crops were sown or planted in a square grid. The plot size was 6.4 m x 8.0 m at 6 plants m^{-2} and 7.0 m x 8.2 m at 10 plants m^{-2}; each plot had 17 and 20 rows in the two populations, respectively. A randomised complete block design with four replications was established. Full details of the crop husbandry operations were given by Hussain (1990).

A total of five harvests were made at about 4 weeks intervals. On each occasion, a randomly selected area of 1 m^2 was harvested from each plot. The beet was divided into leaves (blades + petioles) and the total root. The roots were washed, dried with a cloth, and the fresh weight of roots and tops were recorded separately. A subsample of 500 g green and 200 g dead leaves was oven-dried to constant weight at 70-80 °C.

Roots of each sample were cut longitudinally into two halves. A subsample of 500 g from one half of the root was finely grated and dried at 70-80 °C to constant weight. A subsample of 500 g of green foliage was

Table 1. Effect of sowing date, plant population and planting method on LAI of sugar beet

Treatment		Harvest date				
		Jan., 10	Feb., 10	March, 15	April, 14	May, 16
Sowing date						
Mid-August	(S1)	4.2	4.1	4.7	2.45	3.0
Md-September	(S2)	3.1	3.9	4.8	2.88	3.0
LSD (5%)		0.52	0.60	0.57	0.55	0.46
Plant population						
6 plants m^{-2}	(P1)	3.0	3.6	4.1	2.39	2.8
10 plants m^{-2}	(P2)	4.3	4.4	5.4	2.94	3.2
LSD (5%)		0.52	0.60	0.57	0.55	0.46
Planting method						
Seed-sown	(T1)	3.3	4.1	4.6	2.7	3.2
2-leaf	(T2)	3.6	4.2	4.5	2.8	2.9
4-leaf	(T3)	4.2	3.7	5.2	2.5	2.9
LSD (5%)		0.63	0.72	0.69	0.66	0.57
Significant effects:						
T1 vs (T2 + T3)		*	NS	NS	NS	NS
T2 vs T3		NS	NS	NS	NS	NS
Mean		3.7	4.0	4.8	2.7	3.0

* = Significant at P = 0.05
NS = Non-significant

taken and leaf area was measured on an area meter (Licor, model 3100).

All statistical analyses were performed using single degree of freedom contrasts (Little and Hills, 1978). The Genstat Statistical Package was used to analyse the data. Comparisons have been used to separate means between sowing dates, plant population and planting methods.

Table 2. Effect of sowing date, plant population and planting method on total dry matter (gm^{-2}) production of sugar beet

Treatment		Harvest date				
		Jan., 10	Feb., 10	March, 15	April, 14	May, 16
Sowing date						
Mid-August	(S1)	1372	1793	2036	2107	2355
Md-September	(S2)	890	1628	1796	1911	2097
LSD (5%)		113	108	166	197	162
Plant population						
6 plants m^{-2}	(P1)	1022	1513	1636	1775	2008
10 plants m^{-2}	(P2)	1240	1907	2197	2243	2444
LSD (5%)		113	108	166	197	162
Planting method						
Seed-sown	(T1)	901	1591	1738	1837	2042
2-leaf	(T2)	1106	1681	1796	2043	2149
4-leaf	(T3)	1386	1859	2215	2148	2487
LSD (5%)		138	133	203	241	199
Significant effects:						
T1 vs (T2 + T3)		**	**	**	*	**
T2 vs T3		**	**	**	NS	**
Mean		1131	1710	1916	2009	2226

* = Significant at P = 0.05

** = Significant at P = 0.01

NS = Non-significant

RESULTS AND DISCUSSION

Leaf Area Index (LAI): The LAI increased steadily to maximum value of 4.8 until the March harvest, and then declined sharply, irrespective of the treatment (Table 1). Non-significant differences were found in LAI between the sowing dates, except that at the first harvest the mid August (S1) sowing had greater LAI than the mid September (S2) sowing. Similarly, the transplanted beet had greater LAI than that of the seed-sown beet at the January harvest, although thereafter differences were non-significant. Both the S1 sowing and the transplanted beet, early in the season, had more leaves plant^{-1} than the S2 sowing and the seed-sown beet, respectively. This enabled the plants in the S1 sowing and the transplanted beet, especially at the 4-leaf stage, to develop the leaf canopy rapidly. The results are consistent with the earlier findings (Scott and Bremner, 1966; Scott *et al.,* 1973). There was no confirmation of the previous findings (Watson and Baptiste, 1938) that the leaf area of a late sown crop reached a maximum than in an earlier sown one (Table 1).

Dry matter production: In the present study, the comparatively superior performance of the•S1 sowing and the transplanted beet in TDM (Table 2) or root DM (Table 4) yields may be associated with higher LAI early in

Table 3. Effect of sowing date, plant population and planting method on leaf dry matter ($g\ m^{-2}$) production of sugar beet

Treatment		Harvest date				
		Jan., 10	Feb., 10	March, 15	April, 14	May, 16
Sowing date						
Mid-August	(S1)	757	753	605	496	483
Md-September	(S2)	495	707	607	572	480
LSD (5%)		65	80	78	104	51
Plant population						
6 plants m^{-2}	(P1)	542	621	524	478	450
10 plants m^{-2}	(P2)	709	835	688	590	514
LSD (5%)		65	80	78	104	51
Planting method						
Seed-sown	(T1)	544	710	582	513	490
2-leaf	(T2)	597	742	570	568	482
4-leaf	(T3)	737	732	666	520	474
LSD (5%)		80	98	96	127	62
Significant effects:						
T1 vs (T2 + T3)		**	NS	NS	NS	NS
T2 vs T3		**	NS	*	NS	NS
Mean		626	728	606	534	482

* = Significant at P = 0.05

** = Significant at P = 0.01

NS = Non-significant

The population of 10 plants m^{-2} had significantly greater LAI than a population of 6 plants m^{-2}, throughout the season. The P2 had more leaves per unit area than those for the P1 population leading to a higher LAI in the former than in the latter. Stevens (1985) reported significant increases in leaf production per unit area, with increasing plant population in New Zealand.

the growing season. Both the S1 sowing and the transplanted beet had more leaves $plant^{-1}$ than the S2 sowing and the seed-sown beet, respectively. This enabled the plants in the S1 sowing and the transplanted beet to develop the leaf canopy rapidly and to intercept more of the available radiation. Similarly the plants established at the 4-leaf stage were superior for both the TDM

(Table 2) and the root DM (Table 4) than those established at the 2-leaf stage. These advantages were probably the direct result of higher LAI early in the season. These results are in line with the earlier findings (Dillon *et al.*, 1971; Martin, 1983).

Table 4. Effect of sowing date, plant population and planting method on root dry matter (g m^{-2}) production of sugar beet

Treatment		Harvest date				
		Jan., 10	Feb., 10	March, 15	April, 14	May, 16
Sowing date						
Mid-August	(S1)	615	1040	1431	1611	1872
Md-September	(S2)	395	925	1189	1340	1617
LSD (5%)		65	90	141	139	135
Plant population						
6 plants m^{-2}	(P1)	480	893	1112	1298	1558
10 plants m^{-2}	(P2)	530	1072	1508	1653	1931
LSD (5%)		65	90	141	139	135
Planting method						
Seed-sown	(T1)	357	881	1156	1324	1552
2-leaf	(T2)	509	939	1227	1474	1667
4-leaf	(T3)	649	1127	1547	1627	2013
LSD (5%)		80	110	173	170	165
Significant effects:						
T1 vs (T2 + T3)		**	**	**	**	**
T2 vs T3		**	**	**	NS	**
Mean		505	982	1310	1475	1744

* = Significant at P = 0.01
NS = Non-significant

ports that agronomic techniques should be developed to extend the growing season still earlier into the spring, to utilise the high early season radiation (Follet *et al.*, 1970).

This study showed that greater sugar beet yields (root DM) can be achieved by transplanting, especially at the 4-leaf stage, which is not possible even with normally seed-sown crop earlier in the season. This may suggest that transplanted beet offers an alternative cultural practice that can accumulate greater thermal time than the normal seed-sown crop. Thus enhancing early season leaf growth and development to intercept more radiation in temperate climates.

Both the TDM (Table 2) and the root DM (Table 4) increased at approximately the same rate at different harvests. It implies that the early-sown crops (S1 sowing) did not stop growing before the late-sown one (S2 sowing), and increased its yield from January until the May harvest at least as much, if not more, than the later sowing. The basis for a higher crop yield might have been created early in the season. This sup-

The consistent decline in leaf DM from mid February (Table 3) for all the treatments may indicate an increase in leaf weight to leaf area ratio or thickening of leaves (Campbell and Viets, 1967; Storer, *et al.*, 1970). Such physiological changes within the sugar beet plant are assumed to be associated with the maturing of the crop as the season progresses. In contrast, the root DM showed a general increase throughout the season irrespective of the treatments (Table 4). At the time of the final harvest, the root weight was still increasing and may have increased further if the harvest date had been delayed.

Both the TDM and its components (leaf and root DM) were markedly influenced by the plant population (Tables 2, 3, 4) at all harvest dates. By the final harvest, the P2 population had a 17.8% higher TDM and a 19.3% higher root DM than that for the P1 population. This may due to a higher leaf area (Table 1) and greater radiation interception achieved by the P2 population compared with the P1 population early in the season.

Although the P2 population had a greater LAI than the P1 population at all the harvest dates (Table 1) indicating the light interception to be similar during the same period. This suggests that further increases in LAI may cause little change, or more rarely, a decrease in crop growth rate. Presumably yield of sugar beet fails to increase when LAI exceeds 3-4 because this is close to optimum for crop growth rate (Goodman, 1968). For maximum DM production, it is important that this should occur early in the season when there is most radiation d^{-1} (Watson, 1971). Leaf area will not contribute equally to yield during all parts of the growth period because of environmental effects on the production and use of photosynthates. Also, the ontogenetic development of the plant may cause photosynthates supply to be especially critical for the growth of the storage root at certain times.

The root DM yield achieved from the transplanted beet was 1840 g m^{-2}, while a maximum yield of 2013 g m^{-2} was produced by the 4-leaf transplants (Table 4). These yields are substantially higher than those observed in other experiments carried out in New Zealand (Amin, 1982; Martin and Drewitt, 1984), despite the fact that the latter were harvested after mid June. The results of this study emphasize the benefits of transplanting beet to lengthen the growing season for sugar beet in New Zealand.

REFERENCES

Amin, M. 1982. The influence of plant density on the growth and yield of fodder beet and sugar beet. Thesis, M.Ag.Sc., Lincoln College, Univ. Canterbury, New Zealand.

Campbell, R.E. and F.G. Viets. 1967. Yield and sugar production by sugar beet as affected by stand density and nitrogen fertilization. Agron. J. 59: 349-354.

Dillon, M.A., D.B. McCaslin and W.R. Schemhl. 1972. Effect of transplanting and cover on growth of sugar beet. Agron. J. 64: 183-186.

Follet, R.F., W.R. Scheml and F.G. Viets. 1970. Seasonal leaf area, dry weight and sucrose accumulation by sugar beets. J. Am. Soc. Sugar Beet. Technol. 16: 235-253.

Goodman, P.J. 1968. Physiological analysis of the effects of different soils on sugar beet crops in different years. J. Appl. Ecol. 5: 339-357.

Hull, R. and K.W. Jaggard. 1971. Recent developments in the establishment of sugar beet stands. Field Crop Abstr. (24) 3: 381-390.

Hussain, A. 1990. Effect of seedling transplanting on yield components of sugar beet. Pak. J. Agri. Sci. 27: 277-282.

Little, T.M. and F.J. Hills. 1978. Agri. Experi. John Wiley & Sons, New York.

Martin, R.J. 1983. Effect of cultivar, sowing date and harvest date on yields and sugar contents of beet on a dryland site in Canterbury. N.Z. J. Exp. Agri. 11: 191-197.

Martin, R.J. and E.G. Drewitt. 1984. The effect of sowing date and harvest date on yields of irrigated sugar beet and fodder beet on two soil types in Canterbury. N.Z. J. Exp. Agri. 12: 185-195.

Scott, R.K. and P.M. Bremner. 1966. The effects of growth, development and yield of sugar beet of extension of growth period by transplantation. J. Agri. Sci. Camb. 66: 379-387.

Scott, R.K., S.D. English, D.W. Wood and M.H. Unsworth. 1973. The yield of sugar beet in relation to weather and length of growing season. J. Agri. Sci. Camb. 81: 339-347.

Stevens, D.R. 1985. The manipulation of sugar beet (*Beta vulgaris* L.) growth and development by paclobutrazol and Mefluidide. M. Appl. Sc. Thesis, Univ. Canterbury, New Zealand.

Storer, K.R., W.R. Schmehl and R.J. Hecker. 1970. Quantitative growth studies with sugar beets, *Beta vulgaris*. J. Am. Soc. Sugar Technol. 15: 709-725.

Watson, D.J. and E.C.D. Baptiste. 1938. A comparative physiological study of sugar beet and mangold with respect to growth and sugar accumulation. I. Growth analysis of the crop in the field. Ann. Bot. 2: 437-480.

Watson, D.J. 1971. Size, structure and activity of the productive system of crops. P. 76-88. In: Potential Crop Production. J.P. Cooper and P.F. Wareing (Eds.), London, Heinemann.

Wickens, R. 1982. Weighing up transplanted sugar beet. British Sugar Beet Review, 50: 59-63.