STUDIES ON THE DISTRIBUTION OF DRY MATTER IN SUGAR BEET

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Effects of transplanting and agronomic treatments (plant arrangement, plant population, sowing date) on partitioning of dry matter were investigated on crops of sugar beet *(Beta vulgaris* L. cv. Amazon) during 1981/82 and 1982/83 seasons at Lincoln, Canterbury, New Zealand. The mean ratio for the transplanted beet was about 16% in 1981/82 and 18% in 1982/83 higher than for the seed-sown beet at the final harvest. The mid-August sowing had about 14% higher root: shoot ratio over the mid-September sowing at the final harvest. The plants established at the 4-leaf stage were superior to those at the 2-leaf stage or the cotyledon stage for the root: shoot ratio in both the seasons. The mean ratio for the 4-leaf transplants was about 8% in 1981/82 and 18% in 1982/83 higher than the 2-leaf transplants at the final harvest. The ratio was similar for both plant arrangements and plant populations, indicating that the proportion of dry matter in the roots was not affected adversely by the treatments.

INTRODUCTION

Partitioning of dry matter (OM) is the main cause of the morphological differences of plant size in sugar beet, and it has a marked influence on economic yield (Snyder and Carlson, 1978). Greater economic yield depends on the ability of a beet plant to partition a high proportion of fixed carbon into its tap root, the economic part of the indeterminate vegetative sugar beet, to produce sucrose.

Increasing OM production in sugar beet will not increase harvestable sugar if the faster growth of the shoot is at the expense of stored sugar. As crop yield is a variable proportion of the OM yield, there is evidence from field experiments that season and agronomic treatments (nitrogen, sowing date, plant density and irrigation) can change the distribution of DM within the crop (Goodman, 1966; Last and Draycott, 1975). The aim of this paper is, therefore, to assess the effect of transplanting and agronomic treatments (plant arrangement, plant population, sowing date) on OM partitioning in sugar beet.

MATERIALS AND METHODS

The experiments were conducted at the Lincoln College Research Area during the 1981/82 and 1982/83 seasons following randomised complete block design with four replicates each year. In 1981/82, the treatments were two plant arrangements (square, rectangle) and four planting methods (seed-sown, cotyledon, 2-leaf, 4-leaf). The plant density of 10 plants m^{-2} was constant in both the plant arrangements. The plot size was 5.0 m X 6.5 m, and there were 16 and 10 rows in each plot for the square (316 mm X 316 mm) and rectangular (500 mm X 200 mm) planting, respectively. In 1982/83, the treatments were two sowing dates (mid-August, mid-September), two plant populations (6 plants and 10 plants m^{-2}), and three planting methods (seed-sown, 2-leaf, 4-leaf). The crops were sown or planted in a square grid. The plot size was 6.4 x 8.0 m at 6 plants m^{-2} and 7.0 x 8.2 m at 10 plants m^{-2}; each plot had 17 to 20 rows in the two populations, respectively. The rows were oriented north-south in both the seasons. Full details of the crop husbandry operations were given previously by Hussain (1990).

A total of seven harvests during 1981/82 and five during 1982/83 were made at about 4 week intervals. On each occasion a randomly selected area of 1 m^2 was harvested from each plot except for the final harvest in the 1981/82 season when the area harvested was 2 m^2. Beet was divided into leaves (blades and petioles) and the total root. The roots were washed, dried with a cloth, and the fresh weight of roots and tops was recorded separately. A sub-sample of 500 g of green and 200 g of dead leaves was

Table 1. Effect of plant arrangement and planting method on changes in root:shoot ratio of sugar beet throughout 1981-82 season

Treatment		Harvest date						
		23 Nov.	15 Dec.	15 Jan.	15 Feb.	18 Mar.	19 Apr.	19 May
Plant arrangement								
Square		0.24	0.83	1.11	1.64	1.93	2.94	3.20
Rectangle		0.24	0.87	1.14	1.54	1.95	2.63	3.30
LSD 5%		0.04	0.09	0.13	0.18	0.13	0.24	0.33
Planting method								
Seed-sown	(T1)	0.14	0.77	0.57	1.33	1.69	2.16	2.85
Cotyledon	(T2)	0.22	0.76	1.22	1.61	1.84	2.82	3.18
2-leaf	(T3)	0.24	0.91	1.36	1.68	2.07	2.93	3.38
4-leaf	(T4)	0.35	0.96	1.34	1.73	2.17	3.21	3.57
LSD 5%		0.06	0.13	0.19	0.25	0.19	0.33	0.46
Significant effects								
T1 vs (T2 + T3 + T4)		**	NS	**	**	**	**	**
T2 vs (T3 + T4)		*	**	NS	NS	**	NS	NS
T3 vs T4		**	NS	NS	NS	NS	NS	NS
Mean		0.24	0.85	1.12	1.59	1.94	2.78	3.24

* = Significant at P = 0.05.
** = Significant at P = 0.01.
NS = Non-significant.

oven-dried to a constant weight at 70-80° C.

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

The allometric relationship between sugar beet storage root and top was as follows:

Root:Shoot ratio = RW /SW

where RW and SW are root and shoot dry weights, respectively. 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 among sowing date, plant population and planting method have been used to separate means as described previously (Hussain, 1990).

RESULTS AND DISCUSSION

Transplanted beet showed significantly greater values for root:shoot ratio (Tables 1 & 2) than the seed sown beet throughout the seasons. The achievement of a higher LAI, and consequently higher percentage of radiation interception is necessary for high root OM yield (Hussain and Field, 1991). The transplanted beet attained higher LAI early in the season, thus intercepting more radiation compared with the seed-sown beet and had a prolonged duration of root growth. Therefore, more of its OM was distributed to the roots and consequently more sugar production. Similarly, plants established at the 2-leaf or 4-leaf stage were at a greater advantage in terms of high root:shoot ratio than that of the cotyledon transplants.

The data show that treatments did not adversely affect root:shoot ratio. In contrast, all treatments showed increasing trends in this ratio which suggests that maximising radiation interception through higher LAI and production of OM early in the season did not decrease the partitioning of OM to root or sugar yield. The results (Table 2) clearly indicated that at any harvest date, with plants of variable size (either due to sowing date or planting method) there was a high root:shoot ratio. This may suggest that it is not the assimilate supply but the actual size of the plant parts which influences the partitioning of assimilates. This was shown in grafting experiments when the spinach beet root (Thorne and Evans, 1964) or chard root (Rapoport and Loomis, 1985) were replaced by the larger sugar beet roots. Sugar beet produced a large root with both shoot types. Thus the genetic determination of the storage root appears to be a dominant factor in root:shoot relationship in this species. The models developed for assimilate partitioning (Barnes, 1979; Mclaren, 1984) also suggest that the ratio of specific rates of assimilate incorporation into shoot and storage root is constant, and the partitioning of assimilates is dependent on the shoot and storage root weights. Ivins and Bremner (1966) have reported higher root:shoot ratio with early sowing of sugar beet. Similarly, a higher root:shoot ratio for transplanted beet than ones sown directly in the field was noted by others (Scott and Bremner, 1966).

This study provides no evidence for a decline in the root:shoot ratio with higher population (Table 2). In this experiment, at either density, interplant distances were probably maximum for both soil and aerial environments. Therefore, despite evidence of parabolic relationship between the plant density and the yield (Goodman, 1966; Hills, 1972), the P_2 population, in this experiment, caused no change in the harvest index.

Table 2. ElTect of sowing date, plant population and planting method "n root:shoot ratio throughout 1982-83 season

Treatment		Harvest date				
		10 January	10 February	15 March	14 April	16 May
Sowing date						
Mid-August	(SI)	0.84	1.44	2.52	3.44	3.97
Mid-September	(S2)	0.76	1.38	2.11	2.48	3.42
LSD 5%		0.10	0.23	0.45	0.46	0.38
Plant pupulatlon						
6 plants m^{-2}	(PI)	0.85	1.49	2.25	2.85	3.59
10 plants m^{-2}	(P2)	0.75	1.33	2.38	3.06	3.80
LSD 5%		0.10	0.23	0.45	0.46	0.38
Planting method						
Seed-sown	(Tl)	0.64	1.29	2.13	2.74	3.23
2-leaf	(T2)	0.85	1.33	2.34	2.67	3.54
4-leaf	(T3)	0.91	1.60	2.47	3.45	4.31
LSD 5%		0.12	0.28	0.55	0.57	0.47
Slgulllcaut effects						
Tl vs (T2 + T3)		**	NS	NS	NS	**
T2 vs T3		NS	NS	NS	**	**
Mean		0.80	1.41	2.31	2.96	3.70

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

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