A PRELIMINARY INVESTIGATION INTO THE FERTILIZER REQUIREMENTS OF FODDER BEET (*beta vulgaris* L. CV. MONOBLANC) ON SOME CANTERBURY SOILS

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ABSTRACT

A subtractive design was used to identify nutrient deficiencies limiting yields of fodder beet (cv. Monoblanc) on six sites in Canterbury. Yields of fresh roots and total fermentable sugars were limited by withholding nitrogen, phosphate and sodium.

INTRODUCTION

In New Zealand, mangels, fodder beet and sugar beet have for a long time been relatively unimportant forage crops (Hadfield 1952, Claridge 1972). At intervals interest has been shown in sugar beet as a source of domestic sugar. Recently the New Zealand Energy and Research Development Committee (1979) concluded that fodder beet has high potential as a source of liquid transport fuel and recommended that the crop be evaluated further.

Most of the agronomic practices recommended locally for cultivation of beet, are based on overseas experiences. Although some, such as mechanisation of crop establishment and harvest (Dunn, 1971), time of seeding, cultivars, irrigation and use of agricultural lime (Drewitt, 1976) have been investigated locally, other technologies have been adopted without local testing. While some of the untested imported technologies have apparently worked well, the use of others may lead to inadequate or extravagent practices which could limit beet yields and reduce profitability. This is particularly the case in the use of lime and fertilizers. There are marked differences among overseas and local soils and it is unlikely, therefore, that the kinds and quantities of fertilizers required for high yields in overseas beet crops are the same as those needed for the local crop. In view of the uncertainty regarding optimal applications of lime and fertilizers it was decided to identify plant nutrient deficiencies limiting beet yield on Canterbury soils and, subsequently, to determine the optimal rates of those fertilizers shown to be necessary. This paper gives details of the preliminary investigation.

METHODS AND MATERIALS

In the spring of 1979, a simple subtractive fertilizer experiment was established on each of six field sites in Canterbury. Details of each site are given in Table 1. At each site the beet crop was established without fertilizers, with a complete mixture of fertilizers supplying the nutrients N, P, K, Na, Ca, Mg, S, B. Cu, Zn, Mo and Mn and mixtures from which in turn were withheld N, P. K. Na, K. and Na, Ca, B, Ca and B, and the group S, Mg, Cu, Zn, Mo and Mn (Table 2). Details of the fertilizers supplying the test nutrients and the rates of application are given in Table 3. The fertilizer treatments were applied to randomized plots, each 2.5 m x 5.0 m, in twice replicated blocks. Three plots of both 'Control' treatments, i.e. 'Nil' and 'All' were included in each replicate.

TABLE 1: Details of experiental sites, seeding rate and harvest date.

Site	Soil[1]	Soil Analyses [2]	Preceding Crops	Seeding Date	Harvest Date
Templeton	Waimakariri (deep)	5.9, 12.5, 11, 26,8	potatoes	26.9.79	28 & 29.5.80
Winchmore	Lismore	6.1, 10, 4, 14, 13, 8	potatoes	28.9.79	20 & 21.5.80
Methven	Mayfield	6.6, 17, 9, 18, 22, 4	wheat	28.9.79	16 & 19.5.80
Barrhill	Barrhill	5.4, 8, 6, 15, 14, 5	wheat	4.10.79	13 & 14.5.80
Darfield	Chertsey	5.6, 9, 6, 9, 12, 5	rape seed	11.10.79	22 & 23.5.80
Kimberley	Hatfield	5.6, 10, 10, 17, 19-	pasture	25.10.79	9 & 10.6.80

[1] Kear, Gibbs and Miller 1967.
[2] In turn pH, Calcium, Potassium, Phosphate, Magnesium and Sulphate.

TABLE 2: Details of individual nutrient treatments included in field experiments.

Treatment Code	Treatments
1	Nil
2	All (N,P,K,Na,lime, B.S.Mg,Cu,Zn,Mo & Mn)
3	All — N
4	All — P
5	All — K
6	All — Na
7	All — K and Na
8	All — lime
9	All — B
10	All — lime and B
11	All — S,Mg,Cu,Zn, Mo & Mn

TABLE 3: Details of nutrient elements and fertilizers applied in field experiments.

Nutrient	Fertiliser	kg/ha
N	Urea	218
P	*Either superphosphate	375
	or monoclacium phosphate	138
K	Muriate of potash	375
Na	Sodium chloride	375
Ca	Agricultural lime	1000
B	Borax	15
S	*Either superphosphate	375
	or gypsum	285
Mg	Magnesium oxide	100
Cu	Copper sulphate	5
Zn	Zinc sulphate	5
Mo	Sodium molybdate	0.35
Mn	Manganese sulphate	25

*Where both P and S were supplied, superphosphate was applied.
Where P was withheld, gypsum was applied to supply S.
Where S was withheld, monocalcium phosphate was applied to supply P.

At each site, after seedbed cultivation had been completed, lime and all fertilizers except urea (which was applied after the beet had established) were broadcast and harrowed into the seedbed. Pelleted 'Monoblanc' fodder beet seeds were then precision drilled at 10 cm spacings along rows at 50 cm centres. Subsequently the crops were thinned leaving individual beet plants at minimal nominal spacings of 20 cm.

Apart from Winchmore, where a pre-seeding application of lenacil was made, the experimental sites were treated with post-emergence applications of phenmedipham. Unlike lenacil, the latter failed to control weeds and the crops were inter-row cultivated with a small rotary hoe and hand-hoed within the rows.

At Winchmore the crop was twice flood irrigated in December. At other sites the crops were not irrigated.

At harvest, which was from mid-May to early June 1980, beet from a 2 m x 4 m quadrat in each plot were lifted, cleaned and topped. Roots and tops were weighed separately. Sub-samples of the roots was surface washed with water and a longitudinal section of each washed root removed and grated. Sub-samples of the grated root flesh were taken for dry matter and total fermentable sugars determinations.

Dry matter percentages of tops were determined by drying leaf samples for 8 hours at 90 °C. Dry matter percentages of roots were determined by drying grated root flesh for 16 hours at 90 °C. The concentrations of total fermentable sugars were determined by the automated method of Quin, Wright and Woods (1980).

Yield data from individual sites were subjected to analysis of variance. For the overall analysis of variance, mean treatment yields from individual sites were used.

RESULTS

General

Climatic conditions throughout the beet growing season September 1979 to May 1980 were generally more favourable for crop growth than normally experienced in Canterbury. Although rainfall was low in September, December and May, rainfall in October, November, January and March was at least twice the monthly long-term mean. Marginally higher than average temperatures were experienced throughout the period.

At each site the beet crop established well and after control of weeds had been achieved, made satisfactory growth. Generally the crops remained free from pests and diseases though at Templeton and particularly Winchmore, leaf symptoms not unlike beet virus yellows developed.

Root Numbers

The numbers of roots/hectare harvested varied among individual sites (Table 4). At individual sites the number of roots/hectare harvested was not affected by application of fertilizers except at Winchmore, where the root number was reduced significantly (Table 4). Over all sites individual fertilizer treatments had negligible effects on mean root numbers. (Table 5).

Root Fresh Yields

Yields of fresh roots varied appreciably among individual sites (Table 4). At each site, except Kimberley, yields of fresh roots were significantly improved by application of the complete mixture of fertilizers (Table 4).

Over all sites application of the complete mixture of fertilizers gave a significant increase in fresh root yield and the omission of nitrogen, phosphorus or sodium significantly depressed yields of roots (Table 5).

Root Total Fermentable Sugars Concentrations

The concentration of total fermentable sugars in fresh roots varied among sites (Table 4). At individual sites, application of the complete fertilizer mixture had non-significant effects on total fermentable sugars concentrations except at Winchmore where a significant increase resulted (Table 4).

Over all sites the mean effects of individual fertilizer treatments on total fermentable sugars concentration were non-significant (Table 5).

Root Total Fermentable Sugars Yields

The yields of total fermentable sugars from fresh roots varied appreciably among individual sites (Table 4). At all sites, except Kimberley, application of the complete mixture of fertilizers caused significantly higher yields of total fermentable sugars (Table 4).

Over all sites application of the complete mixture of fertilizers caused a significant increase in mean total fermentable sugar yield and the omission of nitrogen or sodium significantly depressed mean yield (Table 5). The lesser decrease in mean overall yield of total fermentable sugars associated with the absence of applied phosphate, failed to reach statistical significance.

TABLE 4: Data for 'Nil' and 'All' fertilizer treatments for individual sites.

Site	Fertiliser Treatment	Root Numbers 000/ha	Root Fresh Yield t/ha	Root Total Sugars Concentration %	Root Total Sugars Yield t/ha	Root Dry Matter Yield t/ha	Tops Dry Matter Yield t/ha
Templeton	Nil	83.8a	43.1bB	15.6a	6.7bB	8.2bB	2.2bB
	All	88.8a	77.0aA	15.6a	12.0aA	14.4aA	3.3aA
Winchmore	Nil	100.8aA	27.8bB	16.7bA	4.6bB	5.4bB	1.6bA
	All	90.0bA	47.8aA	17.6aA	8.4aA	9.7aA	2.2aA
Methven	Nil	86.3a	66.4bB	16.2a	10.8bB	13.2bB	3.1a
	All	86.7a	90.0aA	15.7a	14.1aA	17.7aA	3.6a
Barrhill	Nil	74.2a	39.6bB	15.6a	6.2nN	8.0bB	3.3bA
	All	81.5a	68.2aA	15.2a	10.3aA	13.3aA	4.3aA
Darfield	Nil	63.5a	35.8bA	17.3a	6.2bA	7.9bA	2.2bB
	All	71.3a	47.2aA	17.0a	8.0aA	10.3aA	2.9aA
Kimberley	Nil	71.9a	67.1a	15.0a	10.0a	12.9a	—
	All	64.2a	71.4a	14.0a	10.0a	13.0a	—
Mean	Nil	80.0a	46.7bB	16.1a	7.4bB	9.3bB	2.5bB
	All	81.4a	66.9aA	15.9a	10.5aA	13.1aA	3.3aA
S.E.mean		2.3	3.2	0.2	0.5	0.6	0.1

Table 5: Mean data for individual fertilizer treatments.

Fertiliser	Root Numbers 000/ha	Root Fresh Yield t/ha	Root Total Sugars Concentration %	Root Total Sugars Yield t/ha	Root Dry Matter Yield t/ha	Tops Dry Matter Yield t/ha
Nil	80.0	46.7	16.05	7.4	9.3	2.5
All	81.4	66.9	15.85	10.5	13.01	3.3
All — N	79.4	51.3	15.89	8.1	10.1	2.2
All — P	81.3	59.2	16.24	9.6	11.9	3.2
All — K	76.6	64.9	15.92	10.2	12.7	3.3
All — Na	80.6	56.7	15.98	9.0	11.5	3.1
All — K & Na	79.7	59.6	16.23	9.6	12.0	3.3
All — lime	78.0	65.1	16.22	10.4	12.9	3.1
All — B	78.0	63.0	16.18	10.1	13.2	3.1
All — Lime & B	78.5	64.8	15.67	10.0	12.7	3.4
All — S,Mg,Cu,Zn, Mo & Mn	77.9	64.3	15.83	10.1	12.6	3.2
LSD 5%	5.6	6.0	0.69	0.95	1.2	0.4

Root Dry Matter Yields

Dry matter yields of roots for individual sites ranked in the same order as fresh root yields (Table 4).

Apart from the Kimberley site, application of the complete mixture of fertilizers resulted in significantly higher yields by root dry matter (Table 4) and over all sites root dry matter yield was significantly limited by withholding either nitrogen or sodium (Table 5).

Tops Dry Matter Yields

Dry matter yields of tops varied among individual sites (Table 4). With the exception of Barrhill, dry matter yields of tops at the five sites for which there are data, were significantly improved by application of the complete fertilizer mixture (Table 4). Of the nutrients withheld only nitrogen had a significant effect on the dry matter yield of tops (Table 5).

DISCUSSION

In this preliminary investigation beet yield parameters varied appreciably among individual sites indicating strong local environmental effects which were not offset entirely by crop responses to applied nutrients. Moreover each parameter differed in response to applied nutrients. At individual sites and over all sites fertilizers generally had either small, inconsistent or non-significant effects on root numbers and the concentrations of total fermentable sugars. Yields of fresh roots, of total fermentable sugars and of root and top dry matters were, however, significantly depressed by withholding some nutrients especially nitrogen.

It was anticipated that some 80,000 roots/hectare would be optimal for near maximum yields of roots and total fermentable sugars. In the event, among sites there was little relationship between root numbers and yields of either roots or total fermentable sugars. It appears that more local research regarding optimal plant populations in the beet crop, is required.

Yield of total fermentable sugars from roots is a function of the number of roots/hectare, the mean weight of individual roots and the concentration of total fermentable sugars in the roots. Neither the number of roots/hectare nor the concentration of total fermentable sugars was affected by fertilizer treatment and it must be concluded therefore that the effects of fertilizers on yields of total fermentable sugar were due solely to their effects on root growth. Sucrose concentrations in fresh sugar beet roots have been shown to be either improved or reduced by application of nitrogen and generally improved by application of phosphorus and potassium. (Draycott and Cooke, 1966).

In England, after nitrogen, sodium is considered the most important fertilizer in sugar beet cultivation and phosphate is thought to be relatively unimportant (Draycott, 1972). It is also recommended that sugar beet be adequately supplied with both potassium and sodium. In the local experiments, applied nitrogen improved yields of roots and total fermentable sugars most frequently and was followed in turn by sodium and phosphorus. The local results tend to bear out overseas experiences except that potassium had no effect on yields of either roots of total fermentable sugars. Application of potassium cannot, therefore, be recommended locally for fodder beet. On the other hand, had the crops been sown on the older Downs soils on which potassium deficiency is known to be more common, responses to applied potassium might have been recorded, as has been the case on similar soils in South Otago (Stephen, unpublished data).

The number of experiments in this investigation was too few for satisfactory conclusions to be reached regarding relations between soil analyses data and beet yield responses to applied nutrients.

Yields of roots and total fermentable sugars suggest that, apart from sodium, the fodder beet crop's nutrient requirements are not too dissimilar from those of other crops grown locally.

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