Effects of potassium, sodium and chloride fertiliser rates on fodder beet yield and quality in Canterbury

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Abstract

There is renewed interest in fodder beet (*Beta vulgaris* L.) production in the South Island of New Zealand. However, recommended agronomic practices for maximising productivity and quality are limited. Two experiments investigating the effects of different rates (kg/ha) of potassium (K; 150 or 300), sodium (Na; 100 or 200) and chloride (Cl; 240) fertiliser application on fodder beet dry matter (DM) production, nutrient concentration and uptake were carried out at Southbridge (2011) and Bankside (2012), Canterbury, New Zealand. Final DM yield was unaffected by the treatments: averaging 32 t DM/ha at Southbridge and 21 t DM/ha at Bankside. However, there was a significant interaction between K and both Cl and Na, on DM yield at Southbridge. Specifically, yield increased to 38 t DM/ha with Na and decreased to 30 t DM/ha with Cl, in the presence of K. Application of K, Na, and Cl fertiliser increased the respective tissue mineral concentration and respective total uptake for both the bulb and shoot components. Potassium tended to depress crude protein, neutral detergent fibre and ash content of the bulbs and increase the metabolisable energy and soluble sugar. The combination of low fibre and high soluble sugar concentrations puts animals at risk of rumen acidosis. These results suggest that fodder beet crops subjected to high rate of soil and/ or fertiliser K should be supplemented with feed high in crude protein and fibre.

Key words: *Beta vulgaris* L., agronomic practices, mineral concentration, mineral uptake, quality attributes.

Introduction

There is renewed interest in fodder beet (*Beta vulgaris* L.) production in the South Island of New Zealand, especially a strong shift toward use of fodder beet for winter feeding of South Island dairy herds. There is an estimated 6000–10 000 ha of fodder beet grown annually in New Zealand (Chakwizira *et al.* 2012; Matthew *et al.* 2011). Recent research suggests high dry matter (DM) yields of 19–35 t DM/ha (Chakwizira *et al.* 2012; Matthew *et al.* 2011) are attainable in New Zealand. These DM yields are higher than the 10–15 t DM/ha for the traditional winter crops, e.g., kale and swedes (Chakwizira *et al.* 2011; Gowers *et al.* 2006; Wilson *et al.* 2006). The potential to grow more DM per unit area has been the key driver in recent increases in the area under fodder beet production, particularly for the increasing New Zealand dairy herd in the South Island.

In fodder beet, recommended agronomic practices for maximising productivity and quality are under review, especially as crops need to be managed for minimal environmental impact. Stephen *et al.* (1980), working with complete mixtures of nutrients, showed that both bulb and shoot DM were affected by the withdrawal of nitrogen, phosphorus and sodium (Na), but did not respond to the withdrawal of other nutrients. Relevant local research on the effects of chloride fertilisers (Goh & Magat 1989; Magat & Goh 1988), has demonstrated increased tissue mineral concentration and uptake of potassium (K), Na and chloride (Cl) but with variable and inconsistent DM yield response. Although these data are important in understanding the growth requirements for fodder beet in New Zealand, it is not clear whether these responses are due to the effects of single elements or their interactions. Chakwizira *et al.* (2012) showed that Cl application reduced DM yield in the presence of K, contrary to previous reports (Magat & Goh 1988). There is also limited information on the nutritive qualities of fodder beet crops in New Zealand, with the current reports suggesting metabolisable energy (ME) of ≥13 MJ/ kg DM, crude protein (CP) of <10% DM (Gibbs 2011; Matthew *et al.* 2011), soluble sugars (SS) of >60% DM and neutral detergent fibres (NDF) of about 13% DM (Matthew *et al.* 2011). These values are comparable with those reported overseas (Clark *et al.* 1987). Clark *et al.* (1987) have also reported acid detergent fibre (ADF), dry organic matter digestibility (DOMD) and total ash content of 6.8, 83.1 and 7.5% DM, respectively. The primary objective of this study was to investigate the effects of K, Na and Cl applications and their interactions on fodder beet DM yield, mineral composition and uptake.

Materials and methods

The two experiments were located at Southbridge (43°81'S, 172°25'E) on an immature Pallic soil (McLaren *et al.* 2009) in 2010/2011 season and Bankside (43°69'S, 171°97'E), on a Rakaia stony sandy loam soil (Hedley *et al.* 2010) in 2011/2012 season in Canterbury, New Zealand. The Southbridge site had been under perennial ryegrass (*Lolium perenne* L.) pasture between 2005 and 2008, and maize (*Zea mays* L.) followed by triticale (*x Triticosecale* Wittm. ex Camus) in the 2009/10 season. Soil preparation involved conventional cultivation after deep ploughing.

The Southbridge experiment was a randomised complete block design, with nine treatments (Table 1), replicated four times. Seed of fodder beet cv. 'Colosse' was planted on 1 November 2010 with an onion seed drill, at a row spacing of 375 mm to give a plant population of 120 000 plants/ha. Plot sizes were four rows (1.5 m) wide × 15 m long, giving a total experimental area of 0.081 ha. A soil test to 150 mm depth showed that the initial soil fertility was adequate, except for K (Table 2). Basal fertiliser was applied at 250 kg/ha diammonium phosphate (DAP; 18:20:0:2) and 15 kg/ha boronate (10% B). Nitrogen was applied as urea (46% N) at 50 kg N/ha twice, on 15 and 30 December 2010, respectively.

The nine fertiliser treatments (Table 1) were broadcast to the relevant plots 2 days after sowing, followed by a 10 mm irrigation to dissolve the fertiliser into the soil. The treatments consisted of a range of K, Na and Cl application rates. The total nutrient applied was K at 150 or 300 kg/ha to the relevant plots, Na at 100 or 200 kg/ha and Cl at 240 kg/ha to the relevant plots. The different nutrients were sourced from different fertilisers. For example, K was obtained from potassium chloride (KCl; 52% K, 48% Cl) and potassium sulphate (K_2SO_4; 45% K), Na was obtained from sodium chloride (NaCl; 40% Na and 60% Cl) and sodium sulphate (Na_2SO_4; 32% Na). The chloride component of both the K and Na fertilisers, together with calcium chloride ($CaCl_2$; 36% Ca and 64% Cl) were the sources of the chloride nutrient. Gypsum was applied in varying amounts to all plots, excluding the controls (Table 1). This was done to make sure all plots received the same amount of Ca and sulphate, which were in some of the applied fertilisers contributing to the K, Na, and Cl elements.

Total rainfall at Southbridge during the experimental period was 393 mm. An addition 200 mm was added as irrigation throughout the experimental period. The mean temperature was 14.9°C, with the highest temperature of 34.1°C recorded on 6 February 2011 and the lowest temperature of 1.9°C recorded on 31 March 2011.

The Bankside experimental site had been under perennial ryegrass pasture for the previous 5 years. Soil preparation here also involved conventional cultivation after deep ploughing. The methodology

Table 1 The treatment structure and rate of individual minerals applied in fodder beet crops grown at Southbridge and Bankside in Canterbury, in 2010/11 and 2011/12 seasons, respectively.

Treatment		Mineral application rate (kg/ha)		
Number	Structure[1]	K	Na	Cl
1	Control	0	0	0
2	Control+ Gypsum	0	0	0
3	200Na+ Gypsum	0	200	0
4	300K+ Gypsum	300	0	0
5	240Cl+ Gypsum	0	0	240
6	300K, 200Na+ Gypsum	300	200	0
7	100Na, 240Cl + Gypsum	0	100	240
8	150K, 240Cl + Gypsum	150	0	240
9	150K, 100Na, 240Cl + Gypsum	150	100	240

[1]Gypsum was applied together with all the treatments except control to offset the calcium and sulphate components of the some of the sources of the K, Na and Cl nutrients. See text for details.

Table 2 Average soil Quick test results measured before sowing at Southbridge and Bankside sites. All units are in MAF QT units unless specified. The optimum nutrient requirements are for general crop production (McLaren & Cameron 1996).

	pH (mg/kg)	Olsen P (mg/kg)	Ca	Mg	K	Na	Cl (mg/kg)	Available N (kg/ha)
Bankside	5.5	33	7	16	4	4	16	127
Southbridge	5.8	36	7	15	3	9	18	150
Optimum	5.8–6.0	20–25	4–10	8–10	5–8	8+	10–12	100–150

and treatment structures for this experiment are similar to the Southbridge experiment (Table 1), with minor differences as described below. The Bankside experiment was replicated six times and cultivar 'Rivage' was planted at 80 000 plants/ha. Seed were sown with a Stanhay 6 m vacuum drill on 1 November 2011 at a row spacing of 500 mm. The row spacing is the standard with sowing contractors' machinery and hence the low plant population compared with Southbridge experiment, when an onion seeder was used at 375 mm row spacing. Plots were 2 m wide × 16 m long, giving at total experimental area of 0.173 ha. A soil test to 150 mm depth showed that the initial soil fertility was adequate, except for K and Na (Table 2). Basal fertiliser was applied at 250 kg DAP/ha and 15 kg/ha boronate. Nitrogen as urea was applied once, at 70 kg N/ha on 15 January 2012. The nine fertiliser treatments were also broadcast to the relevant plots 2 days after sowing, similar fertilisers to Southbridge experiment being used as sources for K, Na and Cl.

Total rainfall at Bankside during the experimental period was 295 mm. An additional 312 mm was added as irrigation throughout the experimental period. The mean temperature was 14.9°C, with the highest temperature of 29.8°C recorded on 29 November 2011 and the lowest temperature of -2.6°C recorded on 3 May 2012.

For both experiments, herbicides were applied using a 15-litre backpack Knapsack sprayer, on 2 and 10 November 2010 at Southbridge, and on 2 and 13 December 2011 at Bankside, to control a wide range of weeds. The herbicides applied were: Nortron® (a.i. 500 g/L ethofumesate and 80 g/L ethylene glycol) at 1 L/ha, Betanal® Forte (a.i. 160 g/L each of phenmedipham and desmedipham, EC) at 1.2 L/ha and Goltix® DF (a.i. 700 g/kg metamitro) at 1 kg/ha in 250 L of water. The insecticide Lorsban® (a.i. 500 g/L chlorpyrifos EC and 490 g/L hydrocarbon liquid) was applied at 1 L/ha in 200 L of water 6 weeks after sowing in both experiments.

Measurements

At the final harvest, DM yield was determined from a 3 m^2 quadrat (two rows by 4 m length) per plot on 27 April 2011 at Southbridge, and from a 2 m^2 quadrat (two rows by 2 m length) on 28 May 2012 at Bankside. Plant density and total fresh weight per quadrat were determined in the field at each harvest. For both experiments, two plants were retained for determining DM yield and one plant for tissue mineral assessment. These were washed to remove soil and then separated into shoot (leaf and petiole) and bulb fractions. Fresh weights for the partitions were determined before being dried in a fan-forced oven at 90°C until constant weight. The subsamples for tissue analysis were also separated into shoots and bulbs, crushed, immediately freeze-dried then finely ground with a Cyclone Sample Mill (Udy Corporation, Fort Collins, Colorado, USA) to pass through a 1 mm screen and analysed for nutrients by near infrared reflectance spectroscopy at Hills Laboratories Limited, (Hamilton, New Zealand). Effects of treatment on feed quality attributes were determined only for the Bankside crop. These included crude protein (CP; %DM), acid detergent fibre (ADF; %DM) and neutral detergent fibre (NDF; %DM), ash (%DM), metabolisable energy (ME; MJ/kg DM), soluble sugars (SS; %DM) and dry organic matter digestibility (DOMD; %DM).

Data analyses

Data representing total DM, nutrients concentration and uptake from each site were analysed by Analysis of Variance (ANOVA) in GenStat v. 14 (VSN International, Hemel Hampstead, UK). An indication of the variability associated with predicted means is provided by the least significant difference (LSD) at $\alpha = 0.05$. Where values show $P<0.1$, a trend is indicated in the text. Three approaches were used to determine the effect of treatments (Table 1) on total DM, nutrient concentration and uptake. This was necessary to allow factorial comparison of nutrients independently of one another given the treatment structure described above. First, overall treatment effect (Treatment 1-9) was analysed to determine whether at least one of the treatments was different. Then the nutrients were partitioned on a presence/absence basis and analysed as a full factorial design for K, Na and Cl, nested within applied gypsum. For the feed quality responses, Cl was excluded leading to a full factorial of K × Na nested within gypsum. All mineral concentrations are expressed on a dry matter basis (g/kg DM). Mineral uptake was calculated as mineral concentration × DM yield (kg/ha).

Results

Plant establishment was more than 75% of drilled seeds at both sites: averaging 90 000 plants/ha at Southbridge and 70 000 plants/ha at Bankside. There were no significant differences in final DM yields among the treatments (1-9) ($P\geq0.23$) at either site, averaging 32 t DM/ha at Southbridge and 21 t DM/ha at Bankside (Figure 1). However, under the presence/absence factorial regime there was an interaction ($P=0.042$) between K and both Cl and Na (Figure 1) at Southbridge. Specifically, yield increased to 38 t DM/ha with Na and decreased to 30 t DM/ha with Cl, in the presence of K.

The bulbs contained about 70% of the total biomass

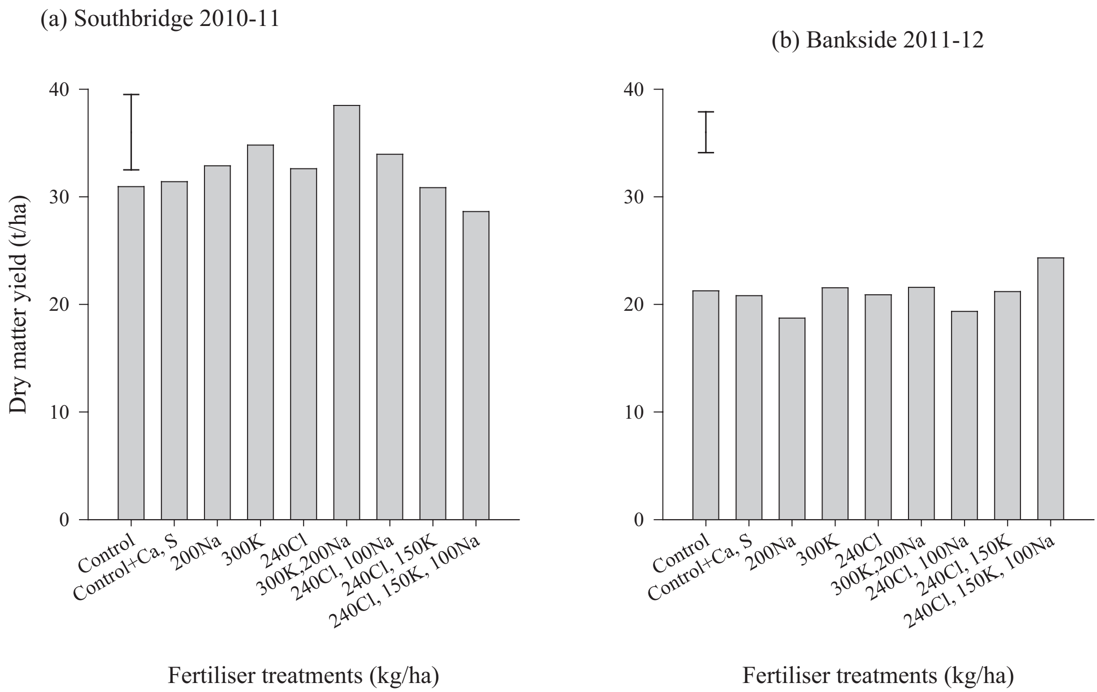

Figure 1 Total dry matter yield for fodder beet crops grown under different potassium (K), chloride (Cl), and sodium (Na) fertiliser rates and combinations at: (a) Southbridge and (b) Bankside in Canterbury in the 2011 and 2012 seasons. The numbers preceding the nutrient symbols are fertiliser amounts applied in kg/ha. Bar represents approximate LSD with 67 d.f. and α = 0.05.

at Southbridge and 83% at Bankside. Mean bulb DM was 17% at both sites. However, leaf DM at Bankside (17%) was twice that at Southbridge.

Mineral uptake and composition

The overall mineral uptake at Southbridge of 522 kg K/ha, 300 kg Na/ha and 423 kg Cl/ha was 70%, 328% and 323% higher ($P<0.001$) than respective mineral uptake at Bankside (Figure 2). However, the application of K, Na and Cl had no significant effect ($P\geq0.12$) on their respective mineral uptake at Southbridge (Figure 2a). At Bankside, Na uptake increased ($P<0.001$) by 42–53% (Figure 2b*ii*) from an average of 60 kg/ha for the control and control + gypsum treatments when Na was applied with or without other minerals. Application of Cl with or without other minerals increased ($P<0.001$) Cl uptake by 129–238% from an average of 58 kg/ha for the control and control + gypsum treatments (Figure 2b*iii*). However, K uptake was unaffected ($P=0.12$) by K application at Bankside.

The application of K, Na, and Cl fertiliser also increased the respective tissue mineral concentration at Bankside (Table 3), but not at Southbridge (data not shown). At Bankside, Na concentration in the bulbs was doubled ($P<0.001$) from 1.2 g/kg DM for the control and control + gypsum treatment to 2.4 g/kg DM for the Na-only treatment. The application of Na in presence of K or Cl increased ($P<0.001$) Na mineral concentration in the bulbs by 67% and 125%, respectively. However, the application of all three elements together had no effect ($P=0.79$) on Na mineral concentration. The leaf Na concentration also increased ($P<0.001$) with application of Na alone. However, leaf Na concentration was not affected by the presence of K or Cl, but increased ($P<0.017$) by 60% in the presence of all three nutrients. The application of all the three fertiliser elements also increased ($P=0.07$) the Na uptake in the leaves. A similar observation was made for the application of K alone.

Application of K caused a marginal increase ($P=0.06$) in both leaf and bulb K concentration (Table 3). Potassium application also increased ($P=0.04$) bulb K uptake but had no effect ($P=0.375$) on leaf K content. Both tissue Cl mineral concentration (Table 3) and content (Figure 2) were increased ($P<0.001$) by the application of Cl fertilisers. As the bulbs contributed most of the total biomass, the total nutrient uptake was proportionally higher in the bulbs.

There was no interaction between K and Na fertilisers on the quality attributes of fodder beet crops (Table 4). There were no treatment effects on any of the variables for the leaf component. Sodium fertiliser had no effect

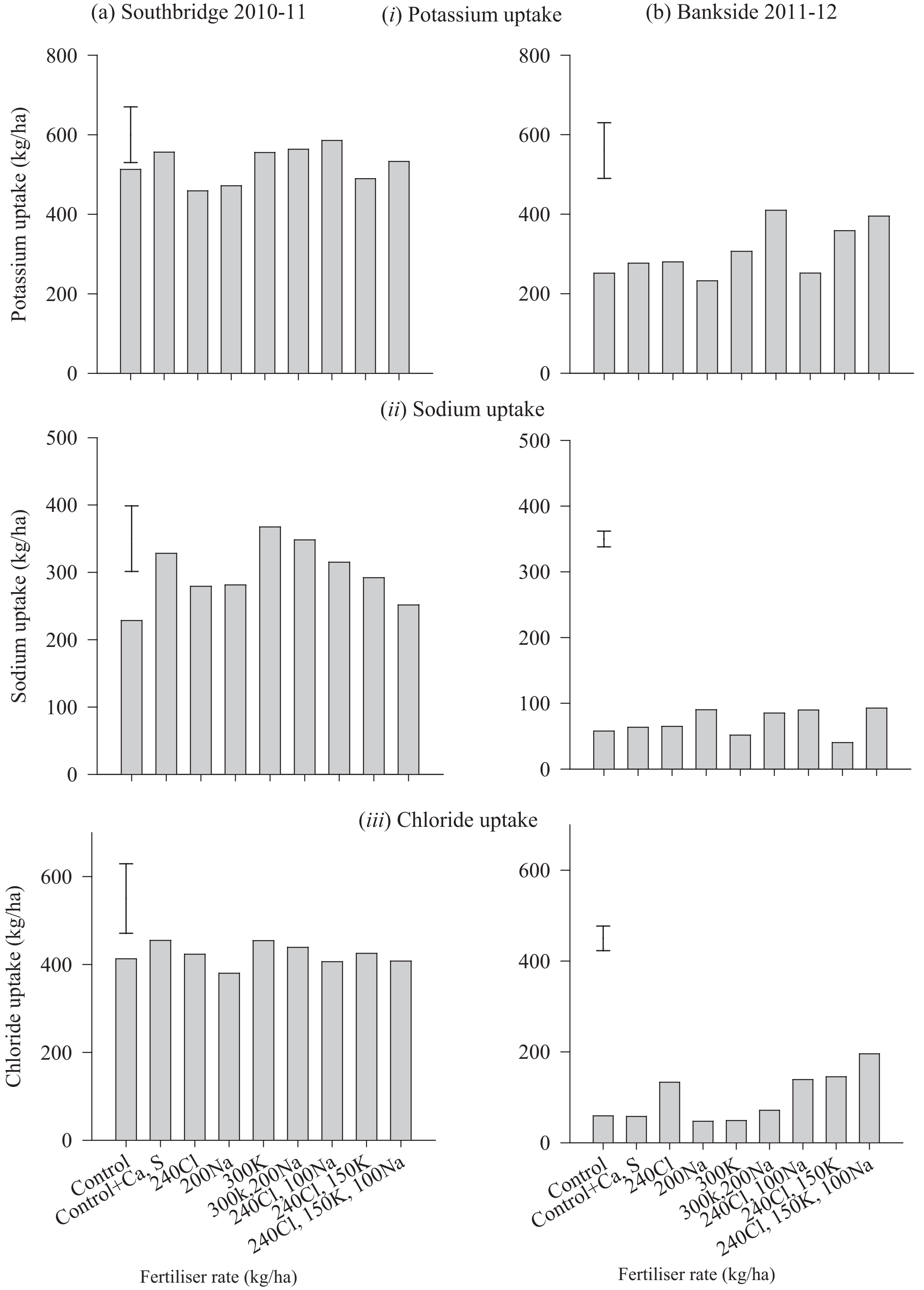

Figure 2 Nutrient uptake (i) potassium (K) (ii) sodium (Na) and (iii) chloride (Cl) by fodder beet crops grown under different K, Na and Cl fertiliser applications rates and combinations at: (a) Southbridge and (b) Bankside in Canterbury in the 2011 and 2012 seasons. The numbers preceding the nutrient symbols are fertiliser amounts applied in kg/ha. Bar represents approximate LSD with 67 d.f. and $\alpha = 0.05$.

on any of the measured quality indicators. However, K tended to depress the CP (P=0.06), NDF (P=0.04) and ash content (P=0.09) of the bulbs and also tended to increase the DOMD (P=0.052), ME (P=0.065) and SS (P=0.054). The CP, NDF and total ash decreased by 7%, 14% and 24% when K was applied, compared with the average values of 8.40%, 9.70% and 4.50%, respectively, for the control and control + gypsum treatments (Table 4). Crude protein, ADF, NDF and ash were greater (P<0.001) in the leaves than in the bulbs, by magnitudes of 1–2 times for CP and 3–5 times for the ADF, NDF and ash. In contrast, the DOMD, ME and SS were higher in the bulbs than the leaves, at 1.5–2 times for the DOMD and ME and 4–6 times for the SS.

Discussion

The overall yield differences of about 50% between the sites may be attributed to either cultivar differences

Table 3 The potassium (K) sodium (Na) and chloride (Cl) tissue mineral concentration (g/kg DM) for the bulb and leaf partitions of fodder beet crops grown at Bankside, Canterbury, in the 2011/12 season.

	Bulb			Leaf		
Treatment[1]	K	Na	Cl	K	Na	Cl
Control	9.7	1.1	0.7	21.7	10.1	12.4
Control+ Gypsum	9.5	1.3	0.8	26.0	11.4	11.9
200Na	11.0	2.4	1.0	20.0	16.9	10.2
300K	10.8	1.0	0.6	32.3	09.3	10.7
240Cl	11.3	1.6	2.1	22.2	10.1	26.3
300K, 200Na	15.3	2.0	1.3	35.0	13.3	13.4
240Cl, 100Na	11.2	2.7	2.5	21.2	13.1	27.3
240Cl, 150K	14.7	0.9	3.1	31.3	07.2	28.7
240Cl, 150K, 100Na	14.2	1.6	3.4	28.2	16.0	33.5
$LSD_{\alpha = 0.05}$	04.3	0.82	1.5	11.6	3.5	7.3
F-pr	0.063	<0.001	<0.001	0.069	0.001	0.001

[1] The numbers preceding the nutrient symbols are fertiliser amounts applied in kg/ha.

Table 4 Feed quality (% DM, unless stated otherwise) for the bulb and leaf partitions of fodder beet crops grown under different potassium (K) and sodium (Na) and chloride (Cl) fertiliser rates at Bankside, Canterbury, in the 2011/12 season and the optimum concentrations for dairy cattle production (Grace *et al.* 2000; NRC 2001).

Bulb	**CP[1]**	**ADF**	**NDF**	**Ash**	**DOMD**	**SS**	**ME (MJ/ kg DM)**
Control (C)	9.70	6.8	10.73	5.37	91.20	55.40	14.60
C + Gypsum	7.07	4.87	8.60	3.63	93.00	68.67	14.90
K	7.80	4.77	8.30	3.40	93.70	74.93	14.97
Na	10.03	6.63	11.00	5.50	90.83	56.70	14.53
K × Na	8.90	4.3	8.93	4.03	92.87	69.23	14.87
$LSD_{\alpha = 0.05}$	2.33	4.21	3.1	2.95	3.25	23.14	0.53
Significance (P=)	0.066	0.13	0.044	0.094	0.052	0.054	0.065
Leaf							
Control (C)	13.53	23.93	32.37	21.6	62.93	11.9	10.07
C + Gypsum	14.23	23.63	33.6	17.17	62.53	10.67	10.03
K	14.93	21.93	30.9	18.4	63.97	13.67	10.23
Na	12.87	23.4	32.7	18.4	64.63	13.5	10.33
K × Na	12.93	24.2	35.83	21.33	60.7	10.67	9.7
$LSD_{\alpha = 0.05}$	5.4	4.05	6.97	7.73	8.63	6.17	1.39
Significance (P=)	0.67	0.64	0.71	0.96	0.60	0.79	0.60
Bulb × Leaf Interaction (P<)	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Optimum	>12	>21	>33	0.5	>70	36–44	10-11

[1]CP=crude protein, ADF=acid detergent fibre, NDF=neutral detergent fibre, DOMD=dry organic matter digestibility, ME=metabolisable energy, SS= soluble sugars

and/or seeding rates. There are no published DM yield data comparing fodder beet cultivars available in New Zealand, but the current results seems to suggest that 'Colosse' yields better than 'Rivage' in Canterbury region of New Zealand. However, the results of 19–35 t DM/ha reported by Matthew *et al.* (2011) suggests that 'Rivage' can yield as much as 'Colosse'. Moreover, the average DM yields of 32 t DM/ha for 'Colosse' at Southbridge and 21 t DM/ha for 'Rivage' at Bankside were within the range reported by Matthew *et al.* (2011) for 'Rivage' at Hawke's Bay in the North Island of New Zealand. The wider row spacing of 500 mm at Bankside ('Rivage') compared with the 375 mm rows at Southbridge ('Colosse') meant that canopy closure was not achieved and there were lower DM yields. This could explain the yield differences between the sites.

The differences in sowing rates and subsequent fodder beet establishment of 9 plants/m^2 at Southbridge and 7 plants/m^2 at Bankside could also have contributed to the differences in DM yields between the sites. Plant density had been shown to influence DM yield in fodder beet crops. In Ireland, Storey & Barry (1983) have reported a 7–14% DM yield decrease as the plant density decreased from 6 to 4 plants/m^2. Similarly, in New Zealand, Martin & Drewitt (1984) have reported a 20% decrease in fodder beet fresh weight as plant density decreased from 7 to 6 plants/m^2.

The proportions of bulb (0.83) and leaf (0.17) to total DM yield, and their respective DM% of about 17% at Bankside were similar to those reported by Matthew *et al*. (2011) and Goh & Magat (1989) for 'Rivage' and 'Trestel' fodder beet cultivars, respectively. The differences in the mean leaf DM% between the sites in the current experiments can be related to the different cultivars used, as Matthew *et al*. (2011) used the same cultivar as at Bankside with the same results.

High mineral uptake at Southbridge than Bankside could be attributed to the low mineral concentration (Table 3) and less DM yield (Figure 1) at Bankside compared with Southbridge (Chakwizira *et al*. 2012). At both sites the concentration of the minerals was consistently greater ($P<0.001$) in the leaf than in the bulbs (Table 3; Chakwizira *et al*. 2012). This is consistent with the reports by Goh & Magat (1989) and Draycott *et al*. (1974). The increase in Cl concentration with application of Cl fertilisers was also consistent with the reports by Goh & Magat (1989). The observation that the amount of nutrient applied mostly meant higher uptake of the respective nutrient was supported by the findings of Magat & Goh (1988). The nutrient concentrations reported for both Southbridge (Chakwizira *et al*. 2012) and Bankside (Table 3) crops were on average within the NRC (2001) dietary recommendation for lactating cows of about 10, 2 and 2.8 g/kg DM for K, Na and Cl, respectively.

Soil type and climatic effects have been cited as major factors contributing to variable yields and mineral uptake in fodder beet crops (Magat & Goh 1988). Both the Southbridge and Bankside experiments were fully irrigated and experienced similar mean temperatures and therefore, it was likely that the differences in DM yield, mineral concentrations and uptake between the experiments may be due to background soil type or cultivar responses. The soils at Bankside are the stony sandy loams with limited depth (McLaren & Cameron 1996) compared to the deeper Pallic soils at Southbridge. This could have effected water and nutrient retention and subsequent availability to the crops; both were less at the Bankside site.

The nutritive qualities reported at Bankside (Table 4) are consistent with those previously reported (Clark *et al*. 1987; Gibbs 2011; Matthew *et al*. 2011). Moreover, with the bulb proportions in excess of 80% of the total DM, the low bulb nutritional values can result in suboptimal CP content for wintering of dairy animals. Gibbs (2011) has reported a minimum CP requirement of 12% and in all cases this was not reached, even after allowing for leaf material that may be fed *in situ*. The same was true for the other quality attributes whose concentrations were low in the bulbs, and would be suboptimal if fed without supplementation. Lower CP and fibres resulting from the low concentrations in the bulbs (Table 4), can be potentially problematic for ration balancing of ruminant feeding (Matthew *et al*. 2011) because of the high SS, low CP and low fibre contents (Table 4). The combination of low fibre and high SS concentrations may reduce rumen pH and put animals at risk of rumen acidosis (Nichol *et al*. 2003). Conversely, the low CP (or nitrogen (N) concentration = CP/6.25; Metson & Saunders 1978) could result in reduced total nitrogen excreted by animals to the environment, compared to the high N (CP) concentration crops such as winter fed brassicas e.g. kale (Fletcher & Chakwizira 2012). The overall low CP may thus not necessarily be bad results considering the animals being fed the crop during this time of the year are under maintenance feeding.

Conclusions

- Fertiliser treatments had no effect on DM yield at both Southbridge and Bankside. Mineral concentrations were higher in the leaves than bulbs. Moreover, the higher bulb proportion (>70% of total DM) may mean low overall nutrient availability to feeding dairy animals. Both Na and Cl application increased their respective tissue mineral concentration and uptake at Bankside but not at Southbridge.

- Fertiliser application effect on feed quality attributes at Bankside was inconsistent; K tended to depress CP, NDF and ash content of the bulbs and increase ME and soluble sugars, while Na had no effect on any of the measured quality attributes. However all measured attributes differed with crop part. For example, CP, ADF, NDF and ash content were higher in the leaves than the bulbs and the DOMD, ME and soluble sugars were higher in the bulbs than the leaves.
- Overall, the fibres and CP were lower than the minimum recommended for dairy cows that are either in late pregnancy or early lactation. The combination of low fibre and high SS concentrations may reduce rumen pH and put animals at risk of rumen acidosis.

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