Effect of nitrogen and phosphate fertiliser on the yield and nitrogen content of Barkant turnips sown as a summer supplementary feed for dairy cows in Taranaki

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Abstract

Fertiliser recommendations in New Zealand for Barkant turnips, as a summer forage crop for dairy cows, are based on Australian research. To validate the Australian results under New Zealand conditions, five trials (two in 1994/95 and three in 1995/96) were conducted in Taranaki to evaluate the growth and yield responses of turnips to nitrogen (N) fertiliser (0, 25, 50, 100, and 200 kg N/ha), phosphate (P) fertiliser (0, 38 and 100 kg P/ha) and soil Olsen P level (28, 48 and 81). All trial sites had an Olsen P greater than 26 and where measured, a total soil nitrogen content greater than 0.63%. From sowing, the accumulation of the components of turnip yield (leaf and bulbs) varied. The accumulation of leaf yield peaked (96 kg DM/ha/day) 70 - 90 days from sowing with no further increase, whereas the accumulation of bulb yield increased at a relatively constant rate through to the end of the 120 day measurement period. All trials exhibited similar trends in response to applied N. Increasing rates of N gave lower ($P<0.05$) bulb yield and higher leaf to bulb ratio ($P<0.05$). Total dry matter yield (ranging from 7 to 12 t DM/ha at 90 days after sowing) was unaffected by N. There was no response to N following a 12 month cropping rotation of turnips/winter greenfeed/turnips. Neither soil phosphate status nor the addition of P had any effect on turnip yield. Plant density at harvest was unaffected by N or P. N and P had variable effects on the total nitrogen content of leaf, bulb and the whole crop. In three of the four trials N increased ($P<0.01$) the nitrogen content of bulbs, however in only one trial was there an increase ($P<0.01$) in leaf nitrogen content. The increase in nitrogen content of bulbs was reflected in an increase ($P<0.05$) in the nitrogen content of the whole crop. In one trial the application of P increased ($P<0.01$) nitrogen content of leaf and bulb. In the other trial no increase was recorded. For moderately high soil fertility sites (Olsen P>26 and total soil N >0.63%) neither nitrogen or phosphate fertiliser are necessary for Barkant turnip crops in Taranaki.

Additional key words: *forage, soil Olsen P, herbage yield, bulb yield*

Introduction

Milk production on a high proportion of dairy farms in New Zealand is limited by the lack of high quality pasture over summer (Penno *et al.*, 1995). In an attempt to maintain milk production over summer, an increasing number of dairy farmers are turning to high yielding forage crops. Barkant turnips, a relatively new white turnip cultivar to New Zealand, are proving to be a popular form of summer forage crop to supplement pasture on dairy farms, especially when cropping is incorporated with pasture renewal.

Research on Barkant turnips in Australia (Notman and Mulvany, 1994) concluded that fertiliser applications of 45 kg P/ha (500 kg/ha superphosphate) and 60 kg N/ha (125 kg/ha urea) were optimum for profitable yield increases. Responses to N of 29 kg DM/kg N were reported at 125 kg urea/ha, and increases in crude protein content from 9.8% (control) to 15.0% (125 kg urea/ha). A response of 32 kg DM/kg P was observed following the application of 500 kg superphosphate/ha to Barkant turnips. Based on these results, the application of 625 kg/ha of 15% potassic superphosphate and 125 kg/ha of urea was recommended to New Zealand dairy farmers (Livestock Improvement Farm Facts No. 36).

To determine if the Australian recommendations were applicable to New Zealand conditions, five trials in South Taranaki were conducted on Barkant turnips to investigate yield and nitrogen content responses to nitrogen (up to 200 kg N/ha) and phosphate fertilisers (up to 100 kg P/ha).

Materials and Methods

Site and Layout

Five trials were conducted in the South Taranaki district. In 1994/95, two trials were conducted on the Taranaki Agricultural Research Station (TARS). The following year, 1995/96, one trial was conducted on TARS, and two on dairy farms in coastal Taranaki. All trials were conducted on soils with good fertility, with two of the trials receiving nitrogen fertiliser in a basal dressing at cultivation. Physical details of the trial sites are presented in Table 1.

The TARS 1994/95 trials investigated the effect of nitrogen fertiliser (N), phosphate fertiliser (P) and soil phosphate levels (Olsen P) on turnip yield. In a split-plot experiment, N (0, 25, 50, 100 and 200 kg N/ha applied as urea) was the main plot with measurement date (50, 70, 90 and 120 days after sowing) as the sub-plot. Another sub-plot of 600 kg/ha of 30% potassic superphosphate (38 kg P/ha and 90 kg K/ha) was evaluated at 90 days after sowing. The trial was replicated four times, with a main plot size of 15 x 4m and sub-plot size of 3 x 4m.

The effect of soil phosphate levels on turnip yield was investigated within the rates of phosphate by stocking rate trial (25, 50 and 100 kg P/ha stocked at 3.6 and 4.2 cows/ha) run at TARS. One, 0.5 ha paddock (10%) within each farmlet, two paddocks/fertiliser rate, was sown into turnips in spring 1994. Yield measurements were taken 96 days after sowing.

The TARS 1995/96 trial was a randomised block design with four rates of N (0, 25, 50 and 100 kg N/ha applied as urea) by two rates of P (0 and 100 kg P/ha applied as triple superphosphate). The treatments were replicated four times with a plot size of 4 x 3m. Yield measurements were taken 90 days after sowing. All trials at TARS were conducted on turnip crops that had been established on soils cultivated from old (greater than 30 years) pasture.

To determine if cultivation in the immediate past influenced response to N, two trial sites were selected on adjacent dairy farms in coastal Taranaki. Site 1 (1995/96) was cultivated for the first time and site 2 (1995/96) had undergone a pasture, turnip, winter crop, turnip rotation over the past twelve months. Both trials were Latin squares, with four rates of N (0, 25, 50 and 100 kg N/ha applied as urea) replicated 4 times (plot size of 4 x 4m). Yield measurements were taken 90 days after sowing.

Table 1. Site descriptions for the four plot trials conducted in Taranaki over the 1994/95 and 1995/96 seasons.

	1994/95 TARS	1995/96 TARS	1995/96 Site 1	1995/96 Site 2
Location	TARS		4 km west of Manaia 2 km from coast	3 km west of Manaia 3.5 km from coast
Altitude	110 m		50 m	65 m
Map Reference	NZMS1 N129/814375	NZMS1 N129/823373	NZMS1 N129/662310	NZMS1 N129/
Geology	Terrace of lower Taranaki ring plain		Uplifted marine terrace	Uplifted marine terrace
Soil Type	Egmont Brown Loam		Egmont Black Loam	Egmont Black Loam strongly mottled subsoil phase
Soil Fertility (after cultivation)	pH=5.5 P=19 K=8 S=90 Mg=16 P=26 pre-cultivation	pH=5.3 P=26 K=8 S=42 Mg=20 Total N% = 0.63	pH=5.7 P=83 K=19 S=111 Mg=34 Total N% = 0.74	pH=6.2 P=32 K=17 S=107 Mg=45 Total N% = 0.81
Paddock History	> 20 yrs in pasture		> 20 yrs in pasture	cropped twice in previous 12 months
Sowing Date	18/11/94	8/11/95	3/11/95	12/11/95
Basal Fertiliser	18 kg/ha of N P K on 14/11/94	none	94 kg K/ha, 39 kg P/ha on 22/10/95	45 kg N/ha, 38 kg P/ha, 45 kg K/ha on 17/10/95
Treatments Applied	12/12/94	5/12/95	6/12/95	6/12/95

Measurements

Yield measurements in all plot trials were taken using a 1 m^2 frame placed randomly three times within each plot. For assessment of yield in the farmlet trial, five randomly placed 1 m^2 frames were used. All the turnips within the frame were removed and leaves and bulbs weighed separately. The number of bulbs were recorded to determine plant density. Sub-samples (two for leaf and one for bulb) were taken from each quadrat, bulked for each plot and mixed to provide a representative sample from each plot to determine dry matter percent (DM%) and total nitrogen content (N%).

To determine DM%, leaves and bulb were dried at 95 °C for 48 hours. Before drying the bulbs were washed to remove soil and then used for analysis of nitrogen content once dried. The other leaf sample was washed and dried for the determination of total nitrogen.

Statistics

All trial results were statistically analysed by analysis of variance using the SAS statistical program. Least squares adjusted means are presented.

Results

Dry matter content and growth

Over all trials the DM% of leaves varied from 7.4 to 16.3% with an average of 10.1% (n=164). Variation in DM content was observed depending on climatic conditions at sampling, eg wilted leaves had a higher DM%. The DM% of bulbs ranged from 5.0 to 11.1% with an average of 7.7% (n=164).

The growth rate of a turnip crop was determined in the TARS 1994/95 trial. For turnips receiving no nitrogen a peak growth rate of 170 kg DM/ha/day was observed in the 70 - 90 days period (Fig. 1). Bulb yield increased linearly over the 120 day measurement period whereas leaf yield increased until around 90 days when growth rate declined. The overall result was an increase in total DM yield over the 120 day measurement period. The rate of increase in total DM yield declined after 90 days. The application of N up to 200 kg/ha (TARS 1994/95) did not change the pattern of growth.

Effect of nitrogen fertiliser

Total yield in the TARS 1994/95 trial (which increased from 4.8 t/ha at 50 days after sowing (DAS) to 11.4 t/ha at 120 DAS) did not differ among N treatments,

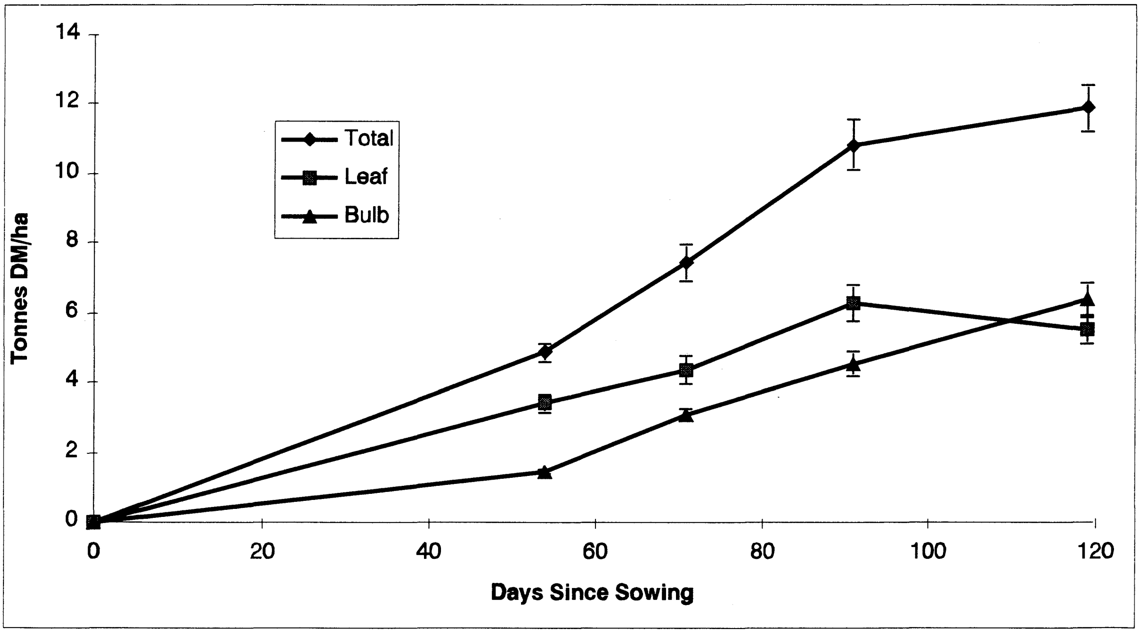

Figure 1. The growth of turnips over 120 days recorded with no nitrogen fertiliser.

and similarly no differences were recorded for leaf yield. At 50 DAS bulb yield did not differ, but at 70, 90 and 120 DAS, bulb yield decreased ($P<0.05$) as N rates increased (Table 2). Decreasing bulb yields and no change in leaf yield meant that leaf:bulb ratio also increased as N rates increased (Table 2).

These results were repeated in the TARS 1995/96 trial and one of the coastal Taranaki trials (Table 3). Total yield (9.9 t/ha at TARS, 10.6 t/ha at coastal site 1, 7.5 t/ha at coastal site 2) was not increased by the addition of N, and once again there was no difference in leaf yield.

Plant density (range 21 - 43 plants/m^2), measured in all trials, was also unaffected by the application of N.

Without N the nitrogen content of turnips in the TARS 1994/95 trial declined from 2.47% at 70 days, to 1.39% at 120 days from sowing (Table 4). The application of N increased the nitrogen content of the total turnip crop in the TARS 1994/95 trial ($P<0.01$) and at site 2 ($P<0.05$) in 1995/96. The increase in nitrogen content was greater in bulbs than in leaves. N increased ($P<0.01$) the nitrogen content of leaves in only one trial (TARS 1994/95) whereas an increase in nitrogen content in bulbs was recorded in three of the four trials.

Effect of phosphate fertiliser

The addition of P did not increase either bulb or total yield. In the TARS 1994/95 trial, P increased ($P<0.01$) leaf yield and leaf:bulb ratio, but this did not occur in the TARS 1995/96 trial.

P significantly increased the N% of leaves, bulbs and therefore the total crop in the 1994/95 trial, but this response was not recorded in 1995/96 (Table 5).

In both trials there were no significant interactions between N and P for total DM yield and for nitrogen content. Interactions between N and P for leaf and bulb

Table 2. The effect of nitrogen fertiliser on turnip bulb yield and leaf:bulb ratio, 50, 70, 90 and 120 days after sowing (das).

	Bulb Yield (t/ha)				Leaf:Bulb Ratio			
kg N/ha	50 das	70 das	90 das	120 das	50 das	70 das	90 das	120 das
0	1.4	3.1	4.6	6.4	2.4	1.5	1.4	0.9
25	1.4	3.6	4.6	5.4	2.4	1.5	1.3	1.1
50	1.3	3.2	3.7	5.6	2.6	1.6	1.7	1.1
100	1.2	2.7	3.3	4.8	2.9	1.7	2.2	1.4
200	1.3	2.6	3.5	4.1	3.1	2.3	2.2	1.7
Significance	NS	*	*	*	NS	**	**	**
C.V.	-	13	17	15	-	14	18	20
$LSD_{0.05}$	-	0.6	1.1	1.2	-	0.4	0.5	0.4
$LSD_{0.01}$	-	-	-	-	-	0.5	0.7	0.5

Table 3. The effect of nitrogen fertiliser on turnip bulb yield and leaf:bulb ratio from trials in 1995/96.

	Bulb Yield (t/ha)			Leaf:Bulb Ratio		
kg N/ha	TARS	Site 1	Site 2	TARS	Site 1	Site 2
0	3.7	4.8	2.8	1.8	1.2	2.0
25	3.8	5.1	2.2	1.7	1.2	2.2
50	3.6	5.2	2.2	1.7	0.9	2.4
100	3.2	5.0	2.2	2.1	1.2	2.4
Significance	*	NS	*	*	NS	*
C.V	12	-	11	15	-	10
$LSD_{0.05}$	0.4	-	0.4	0.3	-	0.3

Table 4. The effect of nitrogen fertiliser on the total nitrogen content (%) of leaves, bulbs and the whole turnip crop.

Nitrogen (kg /ha)	TARS 1994/95 70 days	TARS 1994/95 90 days	TARS 1994/95 120 days	TARS 1995/96 90 days	Site 1 1995/96 90 days	Site 2 1995/96 90 days
Leaf						
0	3.10	2.58	2.02	2.66	3.09	3.16
25	2.99	2.12	2.30	2.64	2.63	3.48
50	3.53	2.22	3.00	2.83	2.71	3.51
100	3.30	3.03	2.48	2.89	2.81	3.55
200	4.27	3.29	2.54			
Significance	NS	**	*	NS	NS	NS
C.V		12	17			
LSD $_{0.05}$		0.53	0.64			
LSD $_{0.01}$		0.76				
Bulb						
0	1.53	1.43	0.87	1.33	1.58	1.24
25	1.68	1.71	1.15	1.22	1.60	1.47
50	1.53	1.88	1.57	1.45	1.24	1.86
100	2.05	2.24	1.50	1.70	1.76	1.93
200	2.22	2.18	2.16			
Significance	**	*	**	**	NS	**
C.V	12	18	27	15		11
LSD $_{0.05}$	0.34	0.52	0.61	0.23		0.28
LSD $_{0.01}$	0.48		0.85	0.31		0.40
Total						
0	2.47	2.08	1.39	2.19	2.38	2.51
25	2.44	1.93	1.74	2.10	2.16	2.85
50	2.74	2.09	2.32	2.33	1.95	3.02
100	2.82	2.77	2.07	2.49	2.31	3.07
200	3.65	2.95	2.40			
Significance	**	**	**	NS	NS	*
C.V.	15	12	15			9
LSD $_{0.05}$	0.65	0.44	0.46			0.39
LSD $_{0.01}$	0.91	0.61	0.65			

yield occurred in both trials, but no consistent trends were obvious and the interactions are not reported.

Effect of soil Olsen P on yield

Stocking rate had no effect on turnip yield and the stocking rate treatments were combined to assess the effect of different Olsen P levels. No effect of Olsen P on turnip yield was recorded, supporting the plot trial results.

Table 5. The effect of phosphate fertiliser on the total nitrogen content (%) of turnips for two trials at TARS.

kg P/ha	Leaf	Bulb	Total Crop
TARS 1994/95			
0	2.70	1.89	2.38
38	3.20	2.15	2.85
Significance	**	**	**
C.V.	9	13	9
$LSD_{0.05}$	0.18	0.18	0.16
$LSD_{0.01}$	0.26	0.25	0.23
TARS 1995/96			
0	2.78	1.40	2.30
100	2.73	1.44	2.26
Significance	NS	NS	NS

Discussion

The total DM production from turnips for the five trials reported exceeded the average summer pasture production recorded for South Taranaki (Roberts and Thomson, 1984) by over 3 t DM/ha. This gives some justification for the use of the crop to supplement a shortfall to dairy cow requirements over summer.

The growth pattern of the turnip crop showed that leaf growth rate decreased after 90 days and bulb yields continued to increase at a constant rate through to 120 days, the end of the measurement period. The decline in leaf growth after 90 days is possibly due to canopy closure resulting in senescence and decay of lower leaves. Similar trends in leaf and bulb growth were observed by Percival *et al.* (1986). For the trials reported by Percival *et al.* (1986), growth was recorded over a longer period than in the Taranaki trials and total yield was found to peak at 120 days then decline. These results suggest that to achieve maximum feed production, turnip crops should be utilised around 80-100 days from sowing.

No response in total yield to either N, P or soil Olsen P status was obtained in the Taranaki trials. These results contradict results reported by Notman and Mulvany (1994) and in part by Clark (1995) who showed from survey data a positive association ($P<0.01$) between total yield and the amount of N applied, but no association between total yield and rate of P. The lack of a response to N is in agreement with results of trials conducted in the Manawatu and Dannevirke districts reported by Daniels (1995). There are, however, many anecdotal reports of visual responses of turnips to N. The Taranaki trials showed an increase in leaf yield and an associated decrease in bulb yield as the rate of N increased. In terms of visual appearance, the application of N would show an effect that would not be reflected in total dry matter yield.

The soil fertility levels in trials reported by Notman and Mulvany (1994) were not specified. Nitrogen and phosphate responses are more likely in poor soils with low organic matter and low Olsen P. Soil tests from Taranaki indicate that a total soil N% of 0.63 and Olsen P of 26 after cultivation will meet nutrient requirements of turnip crops.

The comparison of responses to N on previously uncropped and cropped soils (the site 1, site 2 comparison in 1995/96) was an attempt to determine if the lack of a response to nitrogen was due to high soil nitrogen levels resulting from the recent cultivation of land that had been in pasture for more than thirty years. The assumption was that soils subjected to a cropping rotation would be lower in soil nitrogen and possibly responsive to nitrogen fertiliser in subsequent crops. This however did not occur as the cropped site (site 2) had a higher soil total nitrogen content (0.81%) than site 1 (0.74%) which had been in pasture for at least 20 years. For both sites no response to nitrogen fertiliser was recorded.

The low crude protein content of turnips reported by Notman and Mulvany (1994) suggests that protein deficiency could limit milk production from cows supplemented with turnips over summer. The application of N could overcome a possible protein deficiency. The dairy cow in mid-lactation requires feed with an average crude protein content of around 16% (ARC 1984). The average crude protein content of turnips not receiving N recorded from the Taranaki trials was 14.3%. However as turnips are used as a supplement to summer pasture (crude protein 18-20%) and usually fed at no more than 50% of daily requirements, the application of N to increase crude protein would not be necessary.

Conclusions

In Taranaki soils with an Olsen P greater than 26 and a total nitrogen of 0.63 %, the application of nitrogen and phosphate fertiliser on turnip crops will:

- not affect total DM yield
- decrease bulb yield
- increase nitrogen content of the total crop
- increase nitrogen content in bulbs more than in leaves.

The results highlight that the general adoption of fertiliser recommendations established in other locations could prove inappropriate without confirmation from locally run trials.

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