Improving brassica crop yields in areas cultivated out of hawkweed

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Abstract

Hawkweeds (*Hieracium* species) presently dominate 500 000 ha of the South Island high country. Their spread threatens the ecology of the tussock grasslands and the livelihood of runholders. Management practices have been partially successful at controlling hawkweed spread, but increasingly runholders are cultivating suitable areas. Crops planted into this environment are usually poor with negligible yield. Over 2 seasons 5 trials investigated the role of nitrogen, lime and molybdenum, boron superphosphate in the growth of soft turnips *(Brassica campestris ssp. rapifera Green Globe)* and Italian ryegrass *(Lolium multiflorum)*. The results showed the importance of nitrogen. The nitrogen response of total yield was curvilinear or linear in every trial. Up to 48 kg DM/kg N was grown when 80 kg N/ha was applied, There was no significant reponse to molybdenum, boron, superphosphate or lime. Vegetation and soils dominated by hawkweeds are low in nitrogen, therefore little nitrogen is released after cultivation.

Keywords: crop yields, dryland, *Hieracium pilosella*, nitrogen, toe slopes, *Brassica campestris* ssp. *rapifera*, tussock grasslands, *Lolium multiflorum*

Introduction

The use of large areas of tussock grassland which support significant wool, beef, prime and store lamb production in the South Island is threatened by hawkweed *(Hieracium pilosella)* incursion. Recent estimates indicate that 500 000 ha are dominated by hawkweed, and in a further one million ha they are conspicuous (McMillan 1991; Hunter 1991). Otago and Canterbury contain the bulk of the hawkweed-dominated country. The toe slopes of the ranges provide the majority of the grazing. Because of their strategic value within properties, hawkweed dominance of toe slopes has a strong influence on the viability of the properties. Livestock are unable to extract enough nutrient from hawkweeds for maintenance needs. As a result an estimated 500 000 stock units have been lost from the high country (McMillan 1991; Hunter 1991; Kerr 1992).

Presently the best means of avoiding hawkweed dominance is to establish and maintain a vigorous and dense pasture cover. Run-holders now seek methods which slow the spread of hawkweeds and increase profitability.

Options available to them include oversowing and topdressing, and direct drilling. Results are only partially successful due to re-invasion of hawkweeds. In low rainfall areas hawkweeds continue to spread even in well-managed grasslands, presumably because of the length of dry periods. In well-maintained wetter areas hawkweeds spread whenever there is a prolonged dry period or when economics make it difficult to justify fertiliser input.

As runholders seek solutions, increasingly they look towards traditional cultivation to pasture. First- and second-year brassica crops planted in these circumstances are usually of poor quality and negligible yield, with pastures often slow to establish. Earlier work identified soil pH, nitrogen, phosphorus, sulphur, molybdenum, and boron as most limiting production in the South Island high country (Walker *et al.* 1955; Ludecke 1962; Floate & Enright 1991; Floate *et al.* 1987; Sinclair & Floate 1984). Cossens (1982) summarised the results of brassica trials in Otago and found significant responses to phosphorus and nitrogen.

This paper describes the responses of turnips and Italian ryegrass to applied nitrogen, lime and superphosphate with molybdenum, and boron over two seasons.

Materials and methods

Field trials were carried out in the Paerau district of the Maniototo in both the 1992/93 and 1993/94 seasons. The trials were all 2 X 4 randomised factorials with 4 replicates. There were 5 trials over the two seasons. Fertiliser treatments in each trial are outlined in Table 1. Seeding rate for all trials was 1 kg/ha turnips *(Brassica campestris* ssp. *rapifera* Green Globe) and 6 kg/ha Italian ryegrass *(Lolium multiflorum)*, broadcast on, except in trial 2 when turnips alone were sown. The climate at both sites was similar with annual rainfall of 600-800 mm. Cold winters and mild summers provide only a 6-month growing season. Because it is local practice, a basal application of 375 kg/ha moly boron superphosphate was applied to all plots each year.

Table 1 Treatments applied to trials 1-5.

	Trials 1 and 2		Trial 3 and 4		Trial 5	
Treatment (t/ha)	Lime (kg N/ha)	Nitrogen (t/ha)	Lime (kg N/ha)	Nitrogen Form	N (kg/ha)	O-9-0
1	0	0	0	0	Urea	0
2	0	20	0	40	AmmSul	0
3	0	40	0	80	Urea	125
4	0	80	0	120	AmmSul	125
5	2.5	0	2.5	0	Urea	250
6	2.5	20	2.5	40	AmmSul	250
7	2.5	40	2.5	80	Urea	500
8	2.5	80	2.5	120	AmmSul	500

Trial 5: Examined the influence of rate of superphosphate and form of nitrogen on yield. Nitrogen was applied at a rate of 80 kg N/ha. This site had been cultivated for 2 seasons.

Harvesting was carried out in May when growth had stopped. Plots were cut and weighed, with subsamples taken for dry matter determination.

Initial soil sample results are presented in Table 2.

1992/93 season

Trials 1 and 2 were laid down in November 1992..

Trial 1: Located on Rocklands Station, this site was at 485 m altitude, facing north-west on the eastern side of the Rock and Pillar range. The soil was a Middlemarch yellow-grey earth. This site was ploughed in autumn 1992, and after a winter fallow, was disced into a seed-bed in the spring prior to sowing. With a history of grazing and periodic burning, the block had had minimal inputs. Cover was estimated at 70-80% hawkweed with remnants of hard or silver tussock (*Festuca novae zelandiae*).

Trial 2: Located at Eric and Cate Laurenson's property. This site was at 580 m altitude in a topographical basin facing north east. The soil was a Pukerangi yellow-grey earth, with a history of low-input extensive grazing. This site was bush and bog disced in the autumn, then cultivated to a seed-bed in spring. The cover consisted of 80% hawkweed with some remnants of hard or silver tussock.

1993194 season

Three trials were laid down in November 1993. All were located on the Larenson property on the same site as Trial 2.

Trial 3: Laid on top of trial 2 from the 1992/93 season, with the difference that the lowest rate of nitrogen was replaced by a higher rate of nitrogen. The lowest rate of nitrogen was 40 kg/ha and that was laid on the plots which had 20 kg/ha in trial 2. No additional lime was applied. This site had therefore been cultivated for 2 seasons.

Trial 4: Located on a site that was cultivated in the autumn of 1993, and cultivated into a seed bed prior to sowing in the spring.

Table 2 Initial soil test results.

	pH	Ca	P	K	S	Mg
Rocklands	5.0	4	20	8	2	20
Laurenson	5.0	3	16	9	2	23

Table 3 Economic analysis of trial 1.

Rate of nitrogen kg/ha	0	20	40	80
Cultivation & seed $/ha	230	230	230	230
Fertiliser $/ha	100	125	150	200
Total cost/ha	330	355	380	430
Total DM kg/ha	883	1633	2493	4666
Costs c/kg DM	37	21	15	9
$/bale equivalent (20 kg DM standard bale)	7.40	4.20	3.00	1.80

Results

Increasing rates of nitrogen applied gave increasing total dry matter yields over all the nitrogen treatments applied in trials 1, 2, 3, and 4. Figure 1 demonstrates a significant ($P<0.01$) quadratic response to nitrogen in Trial 1. Figures 3 and 4 show the significant ($P<0.01$) responses obtained in trials 3 and 4 respectively. The response curves are quadratic in trial 3 and linear in trial 4.

In trial 2 (Figure 2) no Italian ryegrass was sown. Because rabbits ate the turnip tops no harvesting was possible. However bulbs were undamaged and were harvested.

Increasing rates of nitrogen applied gave increasing yields of turnip bulbs, over all rates of nitrogen applied in trials l-4 (Figs. l-4).

There were no significant responses in trial 5.

Discussion

Nitrogen has had a positive impact on yields. Hawkweed vegetation is very low in plant nutrients, particularly

Figure 1 Nitrogen response trial 1.

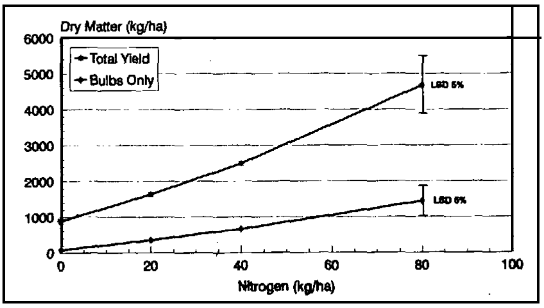


Figure 2 Nitrogen response trial 2.

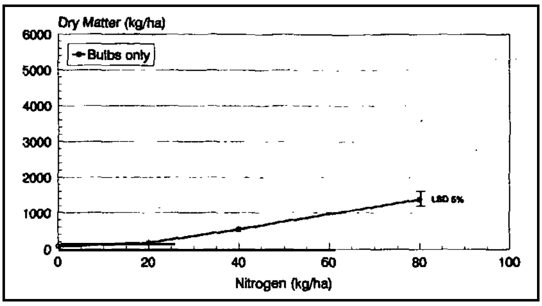


Figure 3 Nitrogen response trial 3.

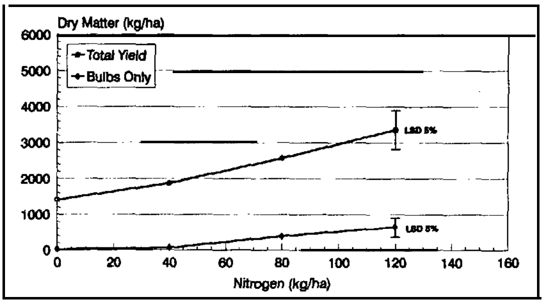
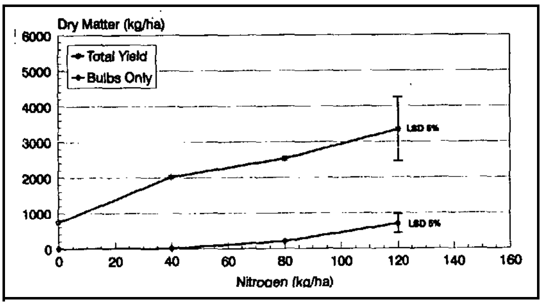


Figure 4 Nitrogen response trial 4.



nitrogen, compared with other plant communities in this environment (Nordmeyer 1993, unpublished data). After cultivation, therefore, less nutrient can be expected to be released from the plant material for recycling into the new soil/plant environment.

The initial soil test results, particularly sulphur levels and soil pH, suggest that the soils used in these trials are in a depleted state. However, phosphate levels, as shown by Olsen P, were in the optimal range.

The trial results illustrate the importance of adding nitrogen when crops are established in this environment. The curvilinear response curve in Figure 1 demonstrates that responses to nitrogen applied at rates higher than 80 kg N/ha may be expected. At Rocklands 20 kg N/ha resulted in 37 kg DM/kg N applied, while 49 kg N/ha yielded 40 kg DM/kg N and 80 kg N/ha yielded 47 kg DM/kg N. The responses in Figures 2, 3 and 4 also indicate that 120 kg N/ha is less than the biological optimium. Yields were lower in trials 3 and 4, owing to higher summer rainfall, lower soil temperatures and quality of the seed-bed at planting.

Nitrogen responses of this magnitude in this environment are recorded in the literature. Cossens (1983) reports responses of between 18 and 50 kg DM/kg N, and also records responses to phosphorus but in conditions of lower soil phosphorus levels than the soils in this study.

Since the response to lime is long term no response was expected and none was measured. The short growth period of the crop did not allow lime to act prior to harvest. However, a response is expected when the lime has had a chance to act when the area is sown into young grass.

Trial 5 demonstrated that there was no response to moly boron superphosphate as applied. This supports the premise that the major growth limitation under the treatments of the trial was nitrogen. The role of P and S in first-year and second-year crops in this environment is therefore questioned. However, it is likely that they will be important in the establishment and growth of pasture and applications during the years of cropping assists in building up soil reserves.

Grazing by rabbits affected plant growth in trial 2. It is possible that yields at Laurenson's would have been similar to those at Rocklands had Italian ryegrass been included in the initial mixture and had rabbits been excluded. This is supported by the data in Figures 1 and 2 which show that bulb yields were similar in trials 1 and 2. Italian ryegrass was included in trials 3, 4 and 5 for this reason the following year.

Results obtained from the trials allow feed cost to be compared. Dry matter grown in trial 1 without nitrogen cost $7.40 per bale equivalent (standard 20 kg bale), while the addition of the 80 kg N/ha results in a reduction of that cost to under $1.80 per bale (Table 3). Similar trends are also evident in the other trials.

Conclusions

Nitrogen is the major nutrient limiting plant growth in these trials. Biological maximum yield was not reached in any trial.

The trial results indicate that, provided adequate nitrogen is used, Italian ryegrass and turnips produce dry matter at a lower cost than hay.

Nitrogen should be used in development strategies for low nitrogen fertility sites. Browntop-dominant pastures and areas low in legumes are examples.

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