ESTABLISHMENT OF WINTER FORAGE CROPS ON PUMICE SOILS – EXPERIMENTAL RESULTS AND FARMERS' PERSPECTIVES

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Abstract

Pastoral production systems can benefit from the incorporation of forage crops to mitigate feed shortages at key times of year. This Sustainable Farming Fund project aims to identify best practice for managing the environmental impacts of forage cropping between pasture phases. This experiment set out to compare conventional establishment of a kale and swede mix (50/50) crop with establishment using direct drill techniques, plus test a range of nitrogen (N) fertiliser application rates (83, and 100, 200, 300 or 400 kg N/ha), and to measure soil N at harvest.

Yields from crops established with direct drill methods were comparable with traditional methods, however direct drilling costs were lower. Total dry matter yield at 200 kg N/ha was c. 11 t DM/ha at harvest (29/5/2012), and increasing N fertiliser did not significantly increase yields. There were some differential effects on the proportions of kale and swede crops at the different N rates; more N fertiliser resulted in a shift from swedes to kale, but not an increase in total yield. Mineral N remaining in the soil at the time of harvest increased with fertiliser N inputs, but amounts were relatively small with a maximum of 37 kg N/ha (0-60 cm) where 400 kg N/ha had been applied. Our assessment was that the N leaching risk from growing the winter forage crop in this year was small. Thus, the key times for minimising the environmental impact of winter forage crops are before the crop (establishment of annual ryegrass in autumn as a lead-in) or after the crop, returning c. 280 kg N/ha to the soil post grazing in winter, with much of that as stock urine.

Keywords

Forage, kale, swede, nitrogen, cultivation, direct drill

Introduction

The inclusion of forage crops into pastoral production systems in the Upper Waikato catchment is one strategy essential to mitigate feed shortages at key times of year. This Sustainable Farming Fund project (SFF11/010) aims to identify best practice for managing the environmental impacts of forage cropping between pasture phases. The transition from old pasture to a cropping sequence, as part of a pasture renewal system, begins in the autumn. To ensure that Browntop (*Agrostis capillaris*) and other weeds and pests are eliminated, the old pasture must be killed off and the soil's weed seed bank reduced. An effective method for achieving this is to use multiple sprays of herbicides and pesticides to kill unwanted plants and pests, and planting forage crops that break pest cycles (e.g. 'The Programmed Approach'; Lane *et al.*, 2009). Discussions with farmers have identified the need for more information around establishment of winter forage brassicas. Traditional cultivation methods are considered more reliable by the farm group (in terms of establishing a viable crop). However, direct drilling, if used correctly, has some potential advantages. Cultivation on pumice soils is detrimental to soil structure, whereas the use of direct drilling to establish a crop has shown benefits such as (Reicosky & Saxton, 2007; Roger-Estrade *et al.*, 2010):

- Increased soil organic carbon, resulting in greater soil water infiltration and drainage; increased cation exchange capacity and soil nitrogen; and reduced erosion.
- Reduced disturbance to soil biota population dynamics and thereby preservation of beneficial disease and pest-regulating relationships.
- Savings in time, labour and fuel usage.

With the development of an appropriate management system, direct drilling can be a suitable alternative to conventional cultivation. The aim of this experiment was to demonstrate on a semi-field scale that direct drilling in an appropriate system can produce at least the same crop yield and provide environmental benefits as well. Another aim was to identify the optimum rates of N fertiliser to apply, and see if these rates differed between establishment methods.

Therefore our hypotheses were:

- Direct drilling can produce the same yield or better as 'conventional' tillage.
- Over-fertilising crop increases risk of N loss post grazing.

Material and methods

Site details

A site near the township of Mangakino, Central North Island, was identified for testing direct drilling vs disc/tine cultivation for crop establishment. This site, on a freely draining pumice soil (Taupo sandy loam), had been sown into a winter ryegrass (Moata) in autumn 2011 using direct drill techniques (Lane *et al.*, 2009), including the application of diammonium phosphate fertiliser (DAP) with the seed. This provided a sound establishment, weed supression, and entry into the winter forage crop phase of the rotation. A month before the establishment of the winter forage began, the paddock was sprayed with herbicide (glyphosate) and cut for silage.

Trial design

In November, the two-way factorial experiment was established in a randomised complete block design with five replicates (50 plots in total):

1. Two cultivation methods for the winter forage crop (50/50 kale/swede mix; 4 kg/ha): direct drilling and 'conventional' tillage (disk, power harrow and sown with roller drill)
2. Five N fertiliser rates: 83, 100, 200, 300 or 400 kg N/ha (or seedbed only, and 50, 100, 150 or 200% of the recommended rate: 200 kg N/ha). The fertiliser recommendations (both N and basal fertiliser rates) came from the local fertiliser representative.

The plots were 12 m wide, to accommodate the sowing and cultivation equpment, and 6 m long with harvests made from areas >1 m from the edges. The treatments received some fertiliser N (83 kg N/ha), as well as basal P and K in the seedbed, either broadcast on the surface (cultivated plots) or applied down the drill as DAP (direct drilled plots). Additional N fertiliser was applied to the plots in January as a single dressing to achieve one of five target rates. All plots were harvested for yield assessement in late May 2012, just prior to when the crop would have been grazed.

Measurements

When the crops reached maturity (28/5/2012), two representative 2.25 m^2 areas were harvested in each of the plots. In one of these areas the yields, %DM, plant counts and %N content were measured. The stem and leaves (in the case of kale), or bulb and leaves (in the case of swedes) were separated for analysis. In the other area, only the fresh yield was measured and the DM yield was calculated from the %DM measured in first area. The total crop N content was calculated separately for swedes and kale as: (leaf %DM x leaf %N) + (bulb or stem %DM x bulb or stem %N). Soil was sampled for mineral N (nitrate-N and ammonium-N) analysis at harvest for 0-30 and 30-60 cm depths on individual plots by bulking 5 cores.

Costs

The cost of establishment using the direct drill or the conventional cultivation method was captured in a spreadsheet and included all of the costs from spraying out the annual ryegrass, to cultivation, to weed and pest management and post emergence fertiliser. Costs of each operation were obtained from the farm manager and the contactor carrying out most of the operations.

Results

Weather

The rainfall data presented is from the interpolated virtual weather data for Mangakino (Tait *et al.*, 2006). Rainfall was above average throughout most of the summer-autumn period, after a drier than average November (Figure 1). The driest periods occurred early December, which was when most of the winter forage crops were establishing, and early February and April. Above average rainfall through the summer and autumn provided good growing conditions. Soils began to cool in April, at which time growth would have slowed.

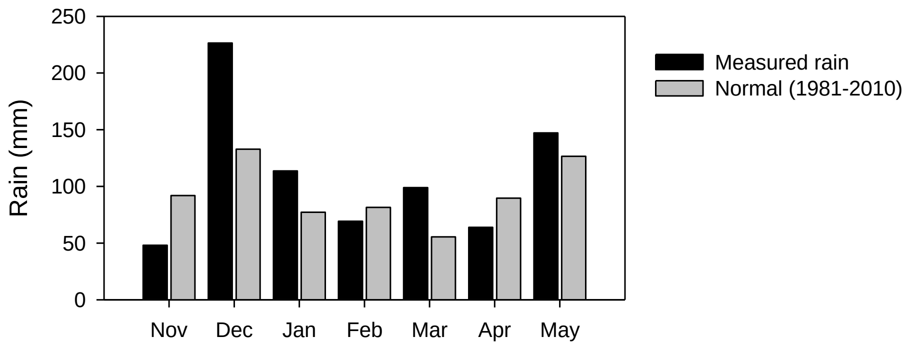

Figure 1. Total monthly rainfall in 2011 - 2012 compared with the 30 year average. (Data source: NIWA)

Crop husbandry costs

A summary of the costs, at the recommended fertiliser rate of 200 kg N/ha, is presented in Table 1. The greatest difference between the two methods was the savings in cultivation costs when direct drilling was used. However, some of that savings were offset against greater sowing and spray (weed and pest) costs, mainly in the form of slug bait which is required for successful establishment with direct drill methods. The costs per kg of dry matter, according to the costs captured in Table 1 worked out to \$0.10/kg DM at 100 kg N/ha, and up to \$0.18/kg DM at 400 kg N/ha.

Table 1. Breakdown of the costs of sowing the swede and kale crop with 100% of the recommended rate of N fertiliser (200 kg N/ha).

Action	**Direct drill** ($/ha)	**Cultivation**
Spray out	152	152
Cultivation	0	305
Sowing	217	177
Starter Fertiliser	316	416
Weed & pest	247	182
Post emergence Fertiliser	549	514
Total	**$1,481**	**$1,746**

Yields

Five different rates of N were tested across the two cultivation treatments to estimate the optimal N fertiliser rate and whether it differed between cultivation systems. Increasing N fertiliser rates did not result in improved total DM yields at the final harvest (*P*>0.05; Figure 2), i.e. there was no effect of N fertiliser rate on total DM yields, there was no effect of establishment system on yield, and there was no interaction of N fertiliser rate and establishment treatment.

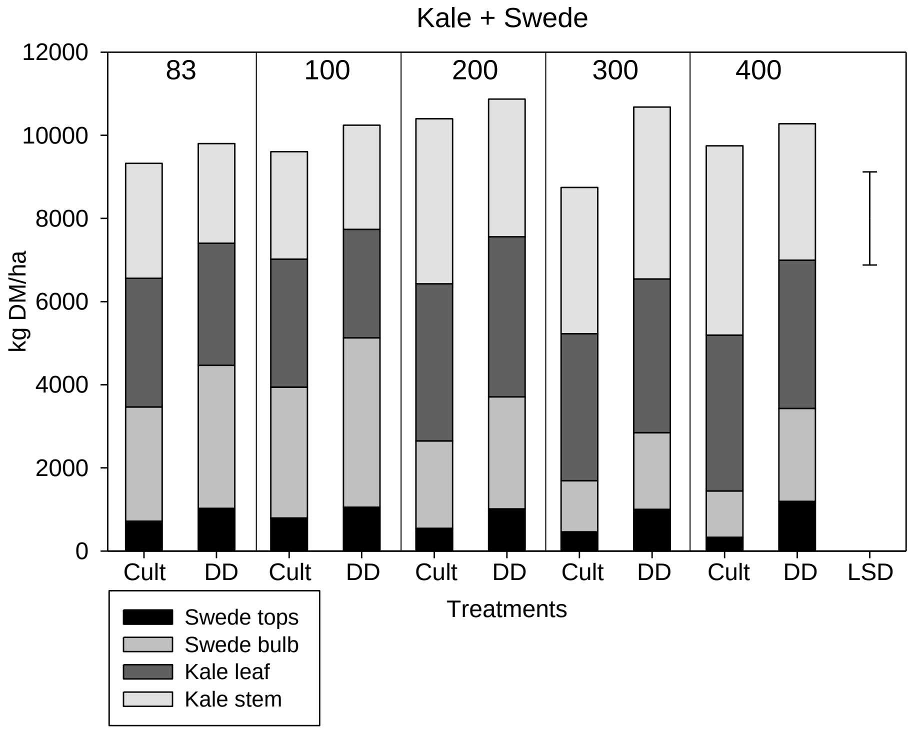

Figure 2. Total yields of kale and swedes were divided into leaf, stem and bulb components. The numbers at the top refer to the rates of nitrogen used in kg N/ha, while at the bottom Cult and DD refer to the sowing treatment (cultivation and direct drill, respectively). Bar represents the LSD (5%) of the cultivation and N application interaction of the whole harvest (kale + swedes, or entire height of the bars).

Nitrogen uptake

The effects of N fertiliser rate and cultivation method significantly affected the total N uptake at the final harvest, but there was no interaction between them (Figure 3). Nitrogen uptake in the harvested plant material increased from 247 to 288 kg N/ha for cultivated and direct drilled, respectively, when averaged across all N fertiliser rates ($P<0.05$). Total N uptake increased with increasing N fertiliser rate as would be expected ($P<0.01$).

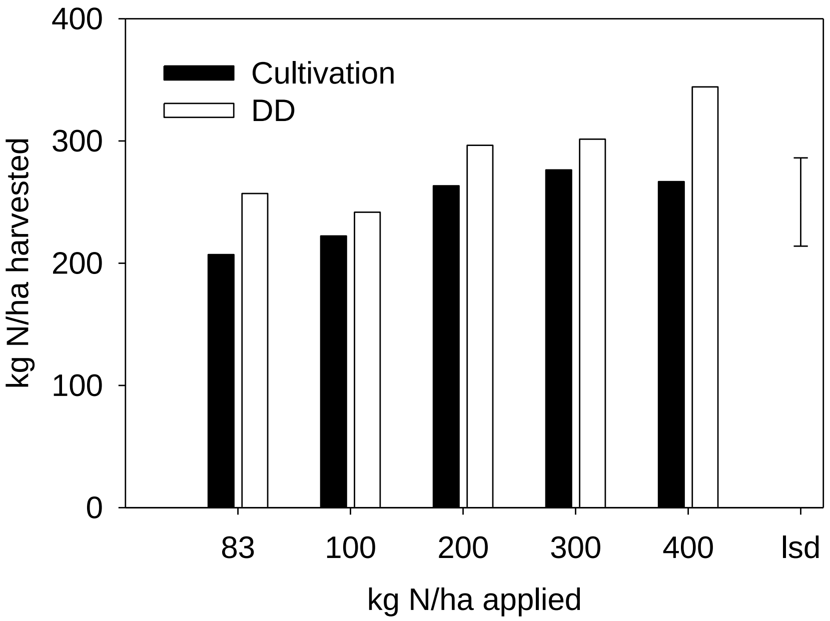

Figure 3. Total N of harvested kale/swede crop with different rates of N fertiliser applied. Bar represents the least significant difference (LSD 5%) of the interaction between the N rate and sowing method.

Soil mineral N

Soil mineral N measured at harvest increased with increasing fertiliser N inputs, as would be expected (Figure 4). Nevertheless, amounts were relatively small, with only 37 kg N/ha measured to 60 cm where 400 kg N/ha had been applied.

This suggests that the applied N has been used by the crop and/or a significant proportion of the N had been immobilised into the soil organic matter. Previous measurements of mineral N on the same farm at the same time of year, under crops fertilised at typical commercial rates, have also been of the same order. It appears that if N is applied at rates ≤ 200 kg N/ha the brassicas will take much of it up. In addition to mineral N, dissolved organic N (DON) might also contribute significantly to N leaching losses (van Kessel *et al*., 2009), although this was not measured.

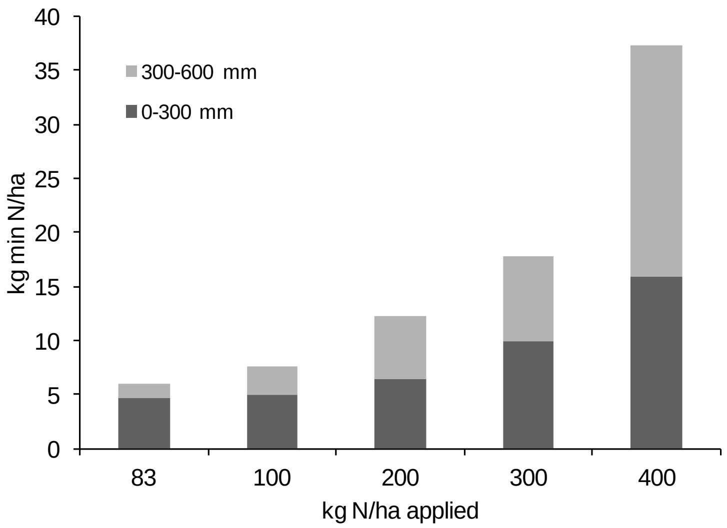

Figure 4. The mineral N remaining in the soil, with depth, at harvest time from the five N treatments (recommended rate was 200kgN/ha).

Farmers' perspectives

The results of this experiment sparked some discussion within the SFF farmers group on the advantages and disadvantages of traditional and direct drilling crop establishment techniques. The normal practice of farmers in the group is to apply two split applications of 100 kg N/ha at 6 and 12 weeks, and they were surprised by the crop yields and minimal leaching risk with one application of 200 kg N. Response to this work has been to reconsider the way nitrogen fertiliser is applied to winter forage crops with a single application in the range of 100 to 200 kg N/ha now recommended, thus reducing application costs with no risk of increased leaching. These preliminary results have also led the group to consider if higher yields would be achieved by growing swedes and kale separately.

Conclusions

The aim of this phase of the project was to understand the impacts of establishing and growing a winter forage crop, in terms of environment, economics and links with other components of the crop rotation. Key messages from this work to date are:

- Direct drilling is a viable means of establishing forage brassica crops in this soil and climatic situation – and offers potential for savings and other benefits.
- Direct drilling is a system that includes spraying out weeds before establishment, sowing the seed with appropriate fertiliser and vigilance for pests and weeds after establishment. As with cultivation, cutting corners could reduce yields and returns.
- The same yield was achieved with direct drilling compared with traditional cultivation methods for the winter forage crop. Savings from establishing crops with direct drilling were estimated to be greater than $200/ha.
- The addition of N did not result in significantly greater yields, rather an increase in kale and a decrease in swedes yields.
- Our assessment was that the N leaching risk during the growing season in this year was small. The remaining soil mineral N in the soil at the end of the growing season, pre-grazing was only 12 kg N/ha at 200 kg N/ha applied fertiliser rate.
- Winter brassicas are effective in removing mineral N from the soil (at recommended fertiliser rates), and therefore growing a good crop is important for removing soil N from the system – but much of this will be returned as urine during winter grazing. There was approximately 280 kg N/ha available in the crop for redistribution in urine

- On the basis of this one experiment, there is no advantage in yield from applying more than the recommended 200 kg N/ha in a combined swede & kale crop.

Thus the challenge for minimising environmental impact comes before the crop (establishment of annual ryegrass in autumn as a lead-in) or after the crop (managing the c. 280 kg N/ha returned to the soil with grazing in winter, with much of that as urine).

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