Best management practice turnip production: how to target a 14 tonne/ha crop on a central North Island dairy farm

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Abstract
A best management protocol for growing a turnip crop was developed from published information and provided to dairy farmers intending to grow the crop. On the basis of information returned by farmers in the 2002/2003 and 2003/2004 growing seasons, the validity of the assumptions underlying the protocol were tested. Many of the returned forms were incomplete and could not be used in the analysis. Adherence to the protocol was variable as farmers interpreted the prescriptive protocol differently and applied components of the protocol as they saw fit on their property. Protocol directions for nitrogen application, soil phosphorus content and sowing rate were applied the most uniformly, providing little variation for testing the impact of these factors. Farmers who applied post-emergence herbicide and insecticide as prescribed achieved a higher ($P<0.01$) turnip yield (on average 12.5 t DM/ha) than those that did not (average 10.9 t DM/ha). Most of this extra yield (1.3 t of the 1.6 t DM/ha) was the result of elevated leaf yields ($P<0.01$) though the leaf:bulb ratio was not significantly affected by following the protocol. We cautiously conclude that following the protocol will be beneficial to farmers. The caution is based on the fact that the results reported did not originate from a controlled experiment, but from a survey where differences in factors such as farming ability and cropping experience were not adequately accounted for between treatments.
Keywords: dairy farming, farmer survey, herbicide, insecticide, summer feed gap, turnip

Introduction
Summer droughts are a regular occurrence in central North Island districts of New Zealand. Drought poses a problem for farmers as pastures wilt, lose their nutritive value and ultimately stop growing. The resulting summer feed gap depresses farm productivity, which in the dairy sector reflects reduced milksolids (MS) production and under-utilisation of processing plants over summer and autumn (Clark *et al.* 1997). Several feed options are available to farmers, ranging from feeding out fresh or stored silage and hay to feeding specialist summer crops that were grown in anticipation of a drought. One such summer crop, turnips, is sown in October or November and is used as a supplement to pasture in February or March when there is a shortage of pasture. Turnips are ideally fed out around 90 days after the crop is sown, depending on variety maturity date. Practically this means that the crop is break-fed from around 80 to 110 days after sowing as it comprises only a proportion of the daily stock diet. The feeding period is a compromise between achieving optimal crop yield and feed quality.

Recorded turnip yields have been variable. A national survey of turnip crops in 1994-95 showed that the average yield was 7.4 t DM/ha (range 0-15.2 t DM/ha, n=328) which is less than the economic break even point of 8-10 t DM/ha (Clark *et al.* 1996). Some of this variation can be attributed to yield potential of different cultivars (Percival *et al.* 1986), variable soil fertility (Hayward & Scott 1993), and a range of sowing dates (Percival *et al.* 1986) and sowing rates (Hayward & Scott 1993). Farming reality dictates that unless reliable economic crop yields are achieved, farmers will lose confidence in a crop. The reasons mentioned above for less than desirable crop yields are all under farmer influence, thus variable crop yields can be partly attributed to variable agronomic expertise (Jacobs *et al.* 2002), and the lack of a single protocol that brings together the management requirements for optimal crop growth.

A best management protocol for growing turnip was developed by M. Lane (Wrightson Seeds) based on published information on crop preparations, timing and sowing, fertiliser application, the timing of post-emergence weed and pest management.

Best management practice protocol
A best management practice turnip production protocol to target a 14 t DM/ha crop is presented in Table 1. The protocol combines appropriate pre-sowing preparations, fertiliser application timing and a weed and pest management strategy. The intention of the protocol is that weed and pest control is carried out pre-emptively on the assumption that when farmers recognise a problem, it is generally too late and that some damage to the crop has already occurred or that damage is unavoidable.

Testing method
Dairy farmers who intended to grow a turnip crop were provided with a copy of the protocol and a crop assessment sheet in the 2002/2003 and 2003/2004

growing seasons. The information returned by dairy farmers, predominantly from the Waikato and northern King Country, was analysed using Genstat (Version 7) and is presented in this paper.

One hundred and eighty eight farmer paddocks were assessed for turnip yields in the 2002/2003 and 2003/2004 seasons and actual farmer actions were compared to actions proposed in the 'Best Management Practice Turnip Production Protocol' to ascertain which actions and their timing are critical to achieving high turnip yields. Farmers intending to grow turnip crops were provided with the protocol and a crop assessment sheet. Data were requested on pre-cultivation spray date, soil preparation, chemicals used and their timing, cultivation techniques used, fertilisers applied and their timing, sowing date, sowing rate, rainfall, paddock contour, soil type and soil fertility data. One hundred and five crop assessment sheets were returned, 70 were incomplete which left 35 that could be used in the analysis. A farmer was considered to have followed the protocol if the timing of the post-emergence herbicide and insecticide was within two weeks of the date prescribed in the protocol. The two week allowance was necessary to avoid spraying during climatic conditions that were likely to depress spraying efficacy.

Turnip yields were assessed by lifting whole turnip plants out of the ground from a single 6 m^2 area that was selected as representative of the crop. In the field, leaf and bulb material were separated, leaf material was cut off the bulb around 1 cm above the neck of the bulb and both leaf and bulb material was weighed immediately after this separation. A sub-sample of the leaf and bulb material was weighed in the field, oven dried for 24 hours at 85 °C and re-weighed to determine dry matter percentages. The majority of the assessed crops were of the variety Barkant.

Results and discussion

The data reported in this paper were not generated from a strictly controlled experiment and need, therefore, to be viewed in the appropriate context. The crops were grown by farmers as part of their commercial operation. Business rather than scientific decisions were made with regards to the need for action. A total of 35 farmers carried out what amounts to single replicates of the experiment.

The difficulty resulting from this lack of control over treatments was that for some treatments virtually all farmers did the same, resulting in limited treatment variation and an absence of contrast between treatments within some of the main factors. For example, all farmers applied at least the amount of nitrogen (N) suggested in the protocol and while some applied more, it is likely that factors other than N became deficient and had a greater impact on yield. Most farmers applied N at sowing and at prescribed times resulting in insufficient variation in the timing of nitrogen application, making it impossible to identify the impact of either the quantity of nitrogen applied or the timing of the nitrogen application. The impact of phosphorus (P) was similarly impossible to discern, as dairy farms typically have high soil Olsen P levels and maintenance P is applied annually. It appears from literature that the importance of fertiliser application is overstated as both Pearson & Thomson (1996) and Hayward & Scott (1993) found that neither N nor P availability to turnips affected yield. Sowing rate variation was perhaps the least of all, generally falling within a narrow band around 3 kg/ha. Jung & Shaffer (1993) found that increasing sowing rate reduced bulb diameter and increased the proportion of yield contained in the leaf, but it did not affect total dry matter yield when the seeding rates were between 2 and 5 kg/ha.

Considerable variation was observed in the timing of post-emergence herbicide and insecticide applications. Generally the two were applied simultaneously. The herbicides used were either Gallant (Caroxylic acid derivative) or Radiate (Substituted pyridine). The insecticides used were predominantly Lorsban (Chlorpyrifos) but Attack (Synthetic pyrethroid and organo-phosphate) and Perfekthion (Dimethoate organo-phosphate) were also regularly used. There was considerable variation between farmers with regards to the timing of the spraying, ranging from within 14 days of the protocol prescription (allowing for unfavourable weather) to up to 60 days later than prescription. The farmers who followed the protocol are assumed to have sprayed pro-actively while the farmers who sprayed later than the protocol suggested were assumed to have sprayed in reaction to an insect or weed problem. This particular aspect of the protocol is likely to have provided farmers with the greatest challenge. On the one hand they did not want to incur the cost of unnecessary spraying while on the other they wanted an optimal high quality crop and reliable yield.

The total turnip (leaf and bulb) yields and leaf yields are given in Table 2.

When the protocol was followed there was only one instance when the yield was less than 10 t DM/ha and in more than 60% of the cases yields were in excess of 12 t DM/ha. In 33% of the cases where the protocol was not followed, yields were under 10 t DM/ha and in only 22% of the cases was the yield in excess of 12 t DM/ha.

In the first year of the survey, numerous farmers did not apply any post-emergence weed and pest control and achieved high yields, on average 14.7 t DM/ha (range 2.9- 20.0 t DM/ha) against 15 t DM/ha for the three farmers who followed the protocol. Rainfall in January and February of the first year was lower (148 mm) than

Table 1 Best Management Practice Turnip Production Protocol.

Action	Conventional	Target 14 t DM/ha
Roundup spraying date	1 November	15 October Apply Lorsban insecticide with Roundup to control springtails. (Check withholding periods)
Seedbed preparation	Develop a cloddy, soft seedbed	Develop a fine, firm weed free seedbed. Make sure the seedbed is rolled
Fertiliser input	2x farm maintenance 20-40 kg N/ha	80-90 kg P/ha 70-80 kg potassium/ha 100 kg N/ha 3-4 kg boron/ha (25 kg Boronate/ha) No sulphur
Lime	Low pH at 5.6-5.8 1 t/ha	Raise pH to 6.0-6.5 3-5 t/ha
Sowing date	15-30 November	15-30 October
Sowing rate	1 kg/ha	2-3 kg/ha (Use SuperStrike treated seed)
Depth of sowing	2-3 cm	< 1 cm
Rainfall	Timing too late for reliable rainfall shortly after sowing	Timing should ensure reliable rainfall shortly after sowing and 3-4 weeks later
Post-emergence weed control	None	Gallant or Centurion Plus for grass weeds, Radiate for broadleaf species at 2-4 weeks after sowing
Insect control	None	Apply a systemic insecticide mixed in with herbicide for aphids, leaf miner etc
Post-emergence fertiliser	None	At 3-4 weeks apply urea at 150 kg/ha
Harvest @ 5 kg DM/cow	1600 grazing days/ha	2800 grazing days/ha
@ 80 gm MS/kg DM	640 kg MS/ha	1120 kg MS/ha
@ 3.50/kg MS	$2240/ha	$3920/ha
Cost of crop, including regrassing	$1445/ha	$2160/ha

Table 2 Total dry matter (DM) and leaf dry matter yields achieved by farmers who applied post-emergence herbicide and insecticide either following the protocol (n = 13) or not (n = 22). Combined results for two years.

	Followed protocol		
	Yes	No	SED
Total yield (t DM/ha)	12.5 (9.7–15.8)	10.9 (7.6–12.4)	0.513
Leaf yield (t DM/ha)	8.1 (7.3–10.8)	6.8 (4.5–8.8)	0.403
Leaf:bulb ratio	1.87 (0.93-3.61)	1.71 (0.62-3.78)	0.145

in the same period in the second year (344 mm) and conditions in the first year may have been more favourable for growing turnips. The high rainfall in the second year created a near optimal environmental for fungal and bacterial development. In a normal year, when the crop reaches full maturity minor insect damage heals over, but in the second year due to extremely high rainfall in the summer, fungal (*Sclerotinia* spp) infestation occurred before insect damaged sites could heal over. The *Sclerotinia* was a precursor of bacteria that cause soft rot (species not identified). The bacterial population developed rapidly and caused crop yields to be depressed in the second year. The environmental conditions in the second year were very unusual, which means that no economic pre-emptive control programme was and will be developed for this situation.

Conclusions

No comments can be made on the impact of many of the potential crop yield determining factors that were targeted in the survey due to insufficient variation in treatment application. Following the protocol guidelines with regards to the timing of post-emergence herbicide and insecticide applications appears to lead to increased crop yields compared to applying these sprays at a later date. However, similarly high yields were achieved in the absence of either spray which raises the importance of farmer experience. It is possible that base soil fertility interacts with the need to use herbicide and insecticide sprays. Crops grown on fertile well managed soils may have a lower need for herbicide and insecticide application than crops grown on low fertility weedy soils, the latter are more likely to be used for forage cropping as part of a pasture renovation programme.

A strictly controlled experiment investigating all important crop production factors is likely to produce valuable insights into optimum soil preparation schedule, sowing time and rate, fertiliser application rate and timing and herbicide and insecticide application timing.

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