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Sweetpotato herbicide trial

—Dargaville

A report prepared for

New Zealand Kumara Distributors Ltd, Vegfed & AGMARDT

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CROP & FOOD RESEARCH
Mana Kai Rangahau

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1 EXECUTIVE SUMMARY

1.1 Project management

This project was initiated and administered by New Zealand Kumara Distributors Ltd (NZKD) and funded by NZKD, the New Zealand Vegetable and Potato Growers' Federation Inc. (Vegfed), and the Agricultural and Marketing Research and Development Trust (AGMARDT). The research provider was the New Zealand Institute for Crop & Food Research Limited (CFR).

1.2 Project report

The kumara research project was funded for two growing seasons (1997/98, 1998/99) and has now concluded. This report details the experimental method and results of a herbicide trial conducted in the Dargaville region in the 1998/99 season. Virus-free plants of the cultivar Owairaka Red were also produced under this project and will be evaluated for root yield and quality under the Foundation for Research, Science and Technology (FRST) funded project, 'Vegetable improvement for sustained industry growth'. The second cycle of clonal selection in Owairaka Red was conducted, but as a minimum of three cycles are required to complete the process, no material has yet been released. This report, accompanied by those listed below, documents the research carried out within this project.

1.3 Publications

Technical reports

Lewthwaite, S. L. 1998: Kumara research project. CropInfo confidential report No. 503. 22p.

Lewthwaite, S. L. and Triggs C. M. 1999: Sweetpotato fertilizer trials - Dargaville. CropInfo confidential report No. 641.

Magazine articles

Brash, D. and Odey, M. 1999: Improving kumara storage techniques. *Commercial Grower 54(4)*: 20-21.

Lewthwaite, S. L. 1998: Mutant kumara. *Commercial Grower 53(2)*: 32-33.

Lewthwaite, S. L. 1998: Improving propagation of kumara. *Commercial Grower 53(10)*: 16, 18.

Lewthwaite, S. L. 1999: Kumara fertilizer and herbicide trials. *Commercial Grower* (in press).

Scientific papers

Lewthwaite, S. L. 1999: Field establishment of sweetpotato transplants. *Proceedings of the Agronomy Society of New Zealand 99* (in press).

2 SWEETPOTATO HERBICIDE TRIAL

2.1 Introduction

Following release of the sweetpotato cultivar Owairaka Red in 1954, commercial production of sweetpotato or kumara in New Zealand increased until there are now over 1000 ha planted each year (Lewthwaite 1997). Generally, sweetpotato are transplanted into the field in November to December and harvested in April to May. The sweetpotato crop is grown on raised moulds or ridges which raise the soil's temperature, improve drainage and aid harvest. The transplants are watered in with tractor-drawn water carts which wet the strip of soil along the crest of the mould. Under these conditions this inter-plant strip develops relatively early weed growth. Sweetpotato plants produce little ground cover over the first month following transplanting and the exposed shoulders of the mould erode, with soil movement sometimes limiting weed growth on the sides of the mould. The hollow between the moulds may then develop weed growth as poorer drainage conserves early rain. Cultivation can be used to keep the base and lower portions of the mould weed-free, but the inter-plant strip is difficult to access. While inter-row cultivation can destroy weeds and aid soil aeration, it may also disturb the sweetpotato plant. When residual herbicides are applied they must form an unbroken film to control weeds, but cultivation or erosion of the soil, along with cracks opening during dry weather, may damage the film and allow weed growth. From mid to late season, sweetpotato plants produce dense ground cover that smothers further weed germination.

The recommended weed control method at the time of Owairaka Red's release was shallow inter-row cultivation (Gillard 1955). The crop generally needed three to four weedings a season, and was hand hoed on the moulds and between plants (Coleman 1972). Although large weeds competed with the crop, deep mechanical weeding could dramatically reduce yield by disturbing the sweetpotato plants. Early New Zealand experimental trials found that sweetpotato plants were fairly tolerant to herbicides, but while the crests and bases of the moulds remained weed-free, the sides did not because of the spray distribution, so shallow herbicide incorporation before moulding was suggested (Webster 1962). The contact herbicide, paraquat, was recommended in 1972, at a rate of 350 - 700 ml/ha (Coleman 1972). Paraquat was applied over the crop while the weeds were small, and although some crop damage always occurred, it was considered less damaging than hand weeding. Gramoxone® (200 g/l paraquat) remains the herbicide most commonly used for weed control in the sweetpotato crop, supplemented by inter-row cultivation and hand weeding.

While there are presently a number of herbicides with label claims for grass control in sweetpotato, alachlor (Foot 1997) which was evaluated in the sweetpotato crop in the Bay of Plenty, Gisborne and Ruawai areas (Scherp 1971) is the only broadleaf herbicide. The Dargaville area produces about 86% of the national sweetpotato crop, but the region has little irrigation water, so is reliant on rainfall. Alachlor is used by some growers, but it requires rain activation (up to 13 mm within 10 days of application) before it can provide 6-8 weeks of residual weed control.

This study evaluated the effectiveness of a range of herbicides for use on sweetpotato in the Dargaville region.

2.2 Disclaimer

This report presents data on exploratory trials involving herbicides. It does not contain recommendations for their use, nor does it imply that the uses discussed here have been registered. The inclusion or absence of trade names in this report implies neither endorsement nor criticism of these products.

3 METHOD

The trial was planted in a commercial field near Dargaville. The site had previously been in grazed pasture. Fertilizer (150 kg/ha of 15% potassic superphosphate and 50 kg/ha of urea) was broadcast in early November 1998. The trial was transplanted into the field on 18 November 1998 and watered in by a tractor-drawn cart. The trial plots were four rows wide by four metres long; only the two middle rows were harvested, the outer rows being buffers. Each row was 0.75 m wide and within-row plant spacing was 0.30 m. The harvested portion of each plot contained a total of 20 plants within a 6 m^2 area. The soil was sampled on 16 December 1998 and the results of the soil analysis were: phosphorus 49 μg/ml, potassium 1.16 me/100 g, calcium 14.7 me/100 g, magnesium 8.02 me/100 g, sodium 0.41 me/100 g, cation exchange capacity 33.3 me/100 g, available nitrogen 187 kg/ha, pH 5.6, and a volume/weight ratio of 0.89 for dried ground soil.

There were 12 treatments (Table 1), each with four replicates arranged in a modified alpha design (Williams & John 1989).

Table 1: Weed control measures evaluated in a sweetpotato trial at Dargaville, 1998/99 season.

Treatment	Active ingredient	Chemical Group	Weed activity	LD50 Dermal (mg/kg)
Hand weeded	N/A	N/A	N/A	N/A
Trophy®	Acetochlor	Acetanilide	Residual	2000
Gramoxone®	Paraquat	Bipyridyl	Contact	236-500
Frontier®	Dimethenamid	Chloroacetamide	Residual	>4560
Magister® + Lasso®	(See below)	(See below)	(See below)	(See below)
Lasso®	Alachlor	Acetanilide	Residual	>5000
Stomp®	Pendimethalin	Dinitroaniline	Residual	>2000
Lentagran® (1.5)	Pyridate	Phenyl-pyridazine	Contact	>2000
Lentagran® (1.0)	Pyridate	Phenyl-pyridazine	Contact	>2000
Magister® (1.0)	Clomazone	-	Residual	2000
Magister® (0.5)	Clomazone	-	Residual	2000
YR160 [1]	Sulphonyurea	-	-	-

[1]Experimental herbicide

The herbicides were applied using a backpack hand-operated sprayer. The spray boom extended over the entire plot width (3 m) and delivered 307 l/ha (Hardi 4110-12 spray nozzles). Eight of the herbicide treatments were applied on the day immediately after transplanting; seven of these treatments were sprayed over the sweetpotato plants (Table 2), while the other (Trophy®) was soil incorporated by hand before transplanting. The three remaining herbicide treatments (Gramoxone, Lentagran® at 1.0 kg/ha and Lentagran® at 1.5 kg/ha) were applied over the sweetpotato plants on 16 December, following transplant establishment and early weed growth.

Table 2: Application details of weed control measures evaluated in a sweetpotato trial at Dargaville, 1998/99 season.

Treatment	Rate	Application time	Activation (type required)
Hand weeded	N/A	As required	N/A
Trophy®	6 l/ha	Pre-transplant	Soil incorporate
Gramoxone®	0.5 l/ha	Post-transplant	None
Frontier®	1.5 l/ha	Post-transplant	Rain (7 mm)
Magister® + Lasso®	0.5 + 3 l/ha	Post-transplant	Rain (13 mm)
Lasso®	4 l/ha	Post-transplant	Rain (13 mm)
Stomp®	3 l/ha	Post-transplant	Rain (12 mm)
Lentagran® (1.5)	1.5 kg/ha	Post-transplant	None
Lentagran® (1.0)	1 kg/ha	Post-transplant	None
Magister® (1.0)	1 l/ha	Post-transplant	Rain (7-8 mm)
Magister® (0.5)	0.5 l/ha	Post-transplant	Rain (7-8 mm)
YR160	60 g/ha	Post-transplant	None

On 7 January, sweetpotato plant survival and phytotoxic effects were recorded, then weed growth was estimated by two randomly placed quadrats in each plot. In each plot, one 0.16 m^2 quadrat was centred on the crest of a mould while the other was centred on a hollow between moulds, and the weeds within them were harvested at soil level. The weeds from each quadrat were then identified, counted and oven dried at 80°C. Following assessment of the weed population and composition, the hand-weeded plots were completely weeded on 7 January with a further weeding on 30 January 1999 (Table 3).

Table 3: The weeds and their frequency within the Dargaville site, as sampled at the hand weeded plots. Some Alligator weed (*Alternanthera philoxeroides*) was also present.

Common name	Botanical name	Botanical family	Occurrence (%)
Redroot	*Amaranthus retroflexus*	Amaranthaceae	76.4
Fathen	*Chenopodium album*	Chenopodiaceae	12.0
Grass	Various	Gramineae	7.6
Creeping mallow	*Modiola caroliniana*	Malvaceae	1.4
Black nightshade	*Solanum nigrum*	Solanaceae	1.1
Staggerweed	*Stachys arvensis*	Lamiaceae	1.0
White clover	*Trifolium repens*	Fabaceae	0.2
Dandelion	*Taraxacum officinale*	Asteraceae	0.1
Scotch thistle	*Cirsium vulgare*	Asteraceae	0.1

Any weeds that germinated under the herbicide treatments were left undisturbed until the trial's completion. The trial was hand harvested and assessed for yield on 14 April 1999. At harvest, all roots were graded either as marketable or waste (less than 2.5 cm diameter and/or distorted, diseased). A sub-sample of three medium-sized roots was removed from each plot and oven dried (20 April) at 80°C to calculate dry matter content. The data were analysed using the Genstat™ statistical software package.

4 RESULTS AND DISCUSSION

A total rainfall of 33.2 mm was recorded at Dargaville (data supplied by the National Institute of Water and Atmospheric Research Ltd) over the 10 day period immediately following spray application (19 November). This rain should have provided adequate moisture for herbicides requiring rain activation. The three herbicide treatments (Gramoxone, Lentagran at 1.0 kg/ha and Lentagran at 1.5 kg/ha) applied on 16 December, after transplant establishment and following early weed growth, all produced various degrees of leaf chlorosis or leaf burn in the sweetpotato plants without causing plant death. None of other herbicide treatments or the hand-weeded treatment showed evidence of any damage to the sweetpotato plants.

The hand-weeded treatment gave the highest total yield (Table 4), but did not differ significantly from the Trophy or Gramoxone treatments ($P > 0.05$). The marketable yield of the hand-weeded treatment was also the highest in the trial, but not significantly different from the Trophy treatment ($P > 0.05$). None of the harvested roots from any treatment showed abnormal cracking or shape distortion. The saleable proportion of the crop and the root dry matter content did not differ significantly between any of the treatments ($P = 0.17$ and 0.79, respectively). Gramoxone appeared to control redroot (*Amaranthus retroflexus*) well, but not fathen (*Chenopodium album*). On a commercial scale, Gramoxone application is often repeated to control both sequential weed germination and robust weeds. Cultivation or hand weeding is used to control escapes of specific weeds such as fathen.

Table 4: Yield characteristics of the sweetpotato cultivar Owairaka Red following single applications of various herbicides, at Dargaville in the 1998/99 season.

Treatment	Total yield (t/ha)	Marketable yield (t/ha)	Saleable proportion (%)	Root dry matter (%)
Hand weeded	27.5	26.7	97.2	29.8
Trophy®	23.5	21.8	92.1	30.6
Gramoxone®	21.5	20.2	93.5	30.7
Frontier®	20.2	19.2	94.1	30.5
Magister® + Lasso®	19.0	18.0	93.7	31.2
Lasso®	18.7	17.5	93.7	30.6
Stomp®	14.8	14.0	93.8	31.4
Lentagran® (1.5)	17.3	16.5	95.4	30.5
Lentagran® (1.0)	14.2	13.3	94.3	30.4
Magister® (1.0)	12.8	12.0	91.9	31.6
Magister® (0.5)	11.7	10.7	92.3	31.3
YR160	11.7	10.7	92.0	30.8
$LSD_{0.95}$	6.0	6.0	3.7	1.9
P-value	<0.001	<0.001	0.17	0.79

The hand-weeded plots effectively contained no weeds after the first weeding session on 7 January and only one further weeding session was required. Five treatments significantly reduced weed numbers relative to the unweeded plots (7 January): Trophy (3.5%), Gramoxone (16.2%), Frontier (21.1%), Magister + Lasso (23.7%) and Lasso (26.2%) (Table 5). Four treatments significantly reduced weed dry weight relative to the unweeded plots (7 January): Trophy (24.1%), Gramoxone (26.8%), Lentagran at 1.5 kg/ha (35.8%) and Lentagran at 1.0 kg/ha (40.2%) (Table 5). However, the plots treated with Lentagran showed reduced weed dry weight due to the general chlorosis of both weeds and crop plants which followed its application, rather than a reduction in weed numbers.

Table 5: Weed characteristics following single applications of various herbicides, in a sweetpotato trial at Dargaville in the 1998/99 season.

Treatment	Weed count[a] (per m^2)	Log weed count	Weed dry weight (g/m^2)	Mean weed dry weight (g)
Hand weeded[b]	712.5	6.5	122.2	0.20
Trophy®	25.0	3.1	29.4	0.98
Gramoxone®	115.6	4.7	32.8	0.24
Frontier®	150.0	5.0	71.6	0.35
Magister® + Lasso®	168.8	5.1	68.4	0.55
Lasso®	193.8	5.2	80.0	0.30
Stomp®	368.8	5.9	113.8	0.31
Lentagran® (1.5)	250.0	5.5	43.8	0.21
Lentagran® (1.0)	337.5	5.8	49.1	0.17
Magister® (1.0)	434.4	6.0	129.4	0.26
Magister® (0.5)	621.9	6.4	111.3	0.27
YR160	246.9	5.5	104.7	0.80
$LSD_{0.95}$		0.98	54.4	0.60
P-value		<0.001	<0.001	0.11

[a] Back-transformed means.

[b] Prior to the first complete weeding on the 7 January, the hand weeded plots were used to estimate the site's weed population and composition. These plots were then maintained weed free by a further weeding on 30 January 1999.

Trophy appeared to effectively control weed germination for a prolonged period without affecting crop growth. Although Trophy required soil incorporation it did not rely on activation by rainfall. Incorporating the herbicide in the soil appeared to make it less vulnerable to soil erosion and movement, as weed control was maintained over the entire plot. Trophy belongs to the same chemical group (acetanilide) as alachlor, which currently has a label claim for use on sweetpotatoes. While plots treated with Trophy contained very few weeds (less than a quarter of those seen in Gramoxone plots) they produced a similar total weed dry weight to plots treated with Gramoxone. Early in the season these plots had a small number of weed escapes which were not hand pulled and grew to become large plants, as can be seen by the mean weed dry weight.

The relationship between early weed count (7 January) and final total yield (14 April) was further examined to see if early weed numbers could be used to predict final yield loss. Some of the chemical treatments reduced weed numbers within individual plots without any obvious effect on sweetpotato growth. Weeds that germinated within the plots were allowed to grow undisturbed and competed with the crop until harvest. The hand-weeded plots (which may have had some mechanical disturbance), and the Gramoxone and the Lentagran plots (which suffered some visible chemical damage) were removed from this analysis. A plot of the logarithm of total yield versus the logarithm of weed count shows a strong multiplicative relationship between early weed count and final total yield ($R^2 = 84.0\%$) (Figure 1). As the weed number doubled, total yield decreased by 18% (s.e. 1.0%)($P < 0.001$).

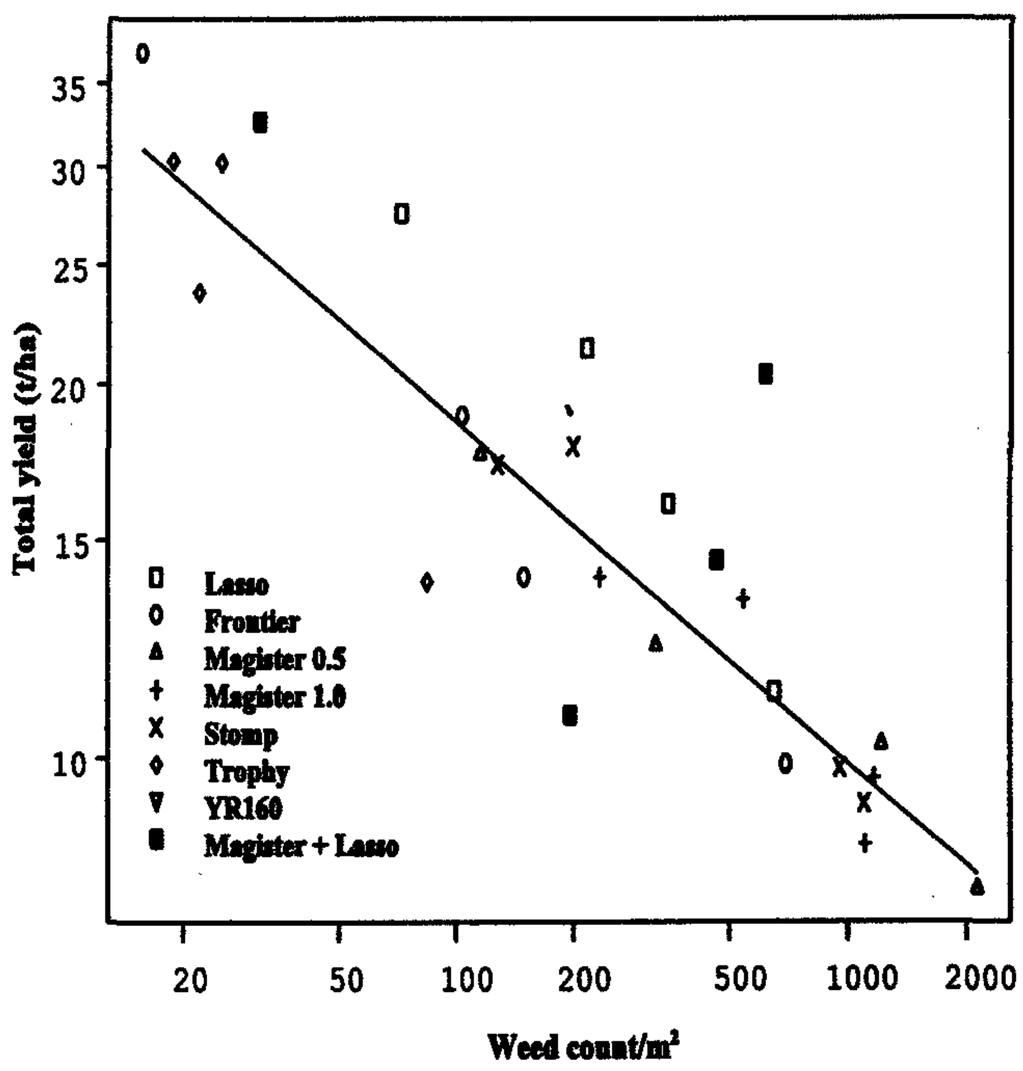

Figure 1: The relationship between early weed count and final total yield in a sweetpotato herbicide trial at Dargaville, 1998/99 season.

This trial examined weed control in a limited way, but further research into developing appropriate weed control strategies, incorporating repeat treatments, variations in application rates and different treatment combinations, will assist in the future management of the sweetpotato crop.

5 SUMMARY

While the range of application rates, application times and weed control combinations were limited, this herbicide trial produced robust results. The herbicide, Trophy, showed definitive control of the weed population represented at the site, without affecting root yield or shape in the sweetpotato crop. Trophy did not require rain to activate, provided a long period of residual weed control, and soil incorporation appeared to solve the problem of weed germination associated with soil movement. Further research on Trophy is required to confirm these results and to ascertain optimum application rates, incorporation methods and crop residue levels at harvest.

Gramoxone is a contact herbicide commonly used in commercial practice. It caused damage to the sweetpotato plants but effectively controlled some weed species while other species such as fathen were not controlled. Because of the specific weed population at this site, other herbicides evaluated in this trial could prove useful for areas with a different weed composition.

An assessment of the early weed population allowed prediction of the final yield loss due to plant competition. Further research in this area could produce management tools that would enable growers to assess the cost-benefit of weed control at low weed population levels.

6 ACKNOWLEDGEMENT

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