CropInfo Confidential Report No. 641

Sweetpotato fertilizer trials

—Dargaville

A report prepared for the

NZ Kumara Distributors Ltd
Vegfed
AGMARDT

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CROP & FOOD RESEARCH
Mana Kai Rangahau

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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).

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 fertilizer trials 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'. A 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.

Publications

Technical reports

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

Lewthwaite, S. L.; Triggs C. M. 1999: Sweetpotato herbicide trial - Dargaville. *CropInfo confidential report no. 642*. 16 p.

Magazine articles

Brash, D.; 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: Aspects of kumara production. *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 FERTILIZER TRIALS - DARGAVILLE

2.1 Introduction

There has been little published research into the fertilizer requirements of the sweetpotato (kumara) crop in New Zealand, and none based on the Kaipara clay soils around Dargaville where 86% of the national crop is grown. Approximately 1050 ha of sweetpotato are grown annually in New Zealand. The crop is mainly sold fresh and is valued at over $16 million (annual household expenditure). As there is a lack of information on fertilizer requirements, New Zealand Kumara Distributors Ltd (NZKD) asked Crop & Food Research (CFR) to conduct a trial in the Dargaville region during the 1998/99 season.

In general, sweetpotato cultivars can be divided into three broad groups based on their fertilizer requirements, namely low, moderate and high nutrient levels. These groups of cultivars roughly correlate with the degree of plant vigour they show in the field, so that the vigorous New Zealand cultivar Owairaka Red can be placed in the low fertilizer requirement group. Of the plant macro-nutrients, nitrogen (N) and potassium (K) are considered to have the most influence on sweetpotato growth and, therefore, yield so they were examined in this trial.

Many experiments have been conducted internationally on the reaction of sweetpotato crops to added nitrogen, but they have given a range of responses, probably due to varying cultivar requirements and soil conditions. One common pattern is that while applying nitrogen at low rates increases yield, higher rates may cause yields to decline. This effect is due to higher levels of nitrogen encouraging excessive growth of the sweetpotato top (vines and leaves) at the expense of storage root yield. However, nitrogen is essential for plant growth and large responses to nitrogen can be obtained on heavily cropped soils, or those subject to heavy leaching. Increasing nitrogen levels may reduce fibre and carotene contents of roots, while increasing root length.

In studies on the effect of potassium, sweetpotato root yields generally show a positive response to additions of potassium fertilizer. Root crops have a high requirement for potassium and heavy cropping can deplete soil levels, so correcting apparently mild deficiencies can result in large yield increases. However, increasing potassium may result in lower sweetpotato root dry matter content. There is some evidence that the addition of potassium can counteract the effect of high nitrogen (Tsuno & Fujise 1964), so in this trial both fertilizers were applied to investigate any possible interaction.

Experience from the USA suggests an applied fertilizer ratio of approximately 1:1.7 (N:K), depending on growing conditions (Jones & Bouwkamp 1992).

3 METHOD

The traditional New Zealand sweetpotato cultivar Owairaka Red was used for these trials and all propagation material was obtained from one grower to reduce genetic variation. The trials were located on neighbouring farms to allow selection of two generally similar sites. One site had a relatively low base level of potassium (K) but a high base level of available nitrogen (N), while the other had relatively high K and low N. The soil at the two sites was sampled on 15 October 1998. Soil analysis results are listed in Table 1.

The trials were planted as row-column designs arranged in rectangular arrays of 6 x 8 and 12 x 4 plots, for Site-1 and Site-2 respectively. The plots were four rows wide by four metres long. Only the two middle rows were harvested, the outer rows being buffers. Each row was 75 cm wide and within row plant spacing was 30 cm. The harvested portion of each plot initially contained a total of 20 plants within a 6 m^2 area. As Site-1 was low in phosphorus (P) relative to Site-2, 79 kg/ha of phosphorus was applied to the entire site as superphosphate (9.1% P). The experimental treatments consisted of four nitrogen rates (0, 25, 50 and 100 kg/ha) applied as urea (46% N) and four potassium rates (0, 100, 200 and 400 kg/ha) using muriate of potash (50% K), at each site. The four nitrogen and four potassium rates were applied in all combinations, to give a total of 16 treatments with three replications, at each site. The fertilizer was spread within each plot by hand, then incorporated with a hand-operated rotary hoe before re-moulding. Site-1 was planted on 20 November and Site-2 on 25 November 1998. The plants were watered in and the sites were managed commercially throughout the season.

Plant survival within each plot was recorded on 8 January 1999. In February, samples of leaves (fifth to seventh youngest leaves) were collected from each plot for tissue analysis (nitrogen and potassium). Site-1 was sampled when it had considerable vine cover between rows (7 February), while Site-2 showed delayed growth and was sampled when vines were just beginning to meet across rows (6 February). Leaf samples from Site-2 were washed to remove silt. The leaf samples were oven dried at 60 °C before being analysed.

Both sites were harvested by hand, Site-1 on 12 April and Site-2 on 13 April 1999. All of the roots were graded either as marketable or waste (less than 2.5 cm diameter and/or distorted, diseased) and roots in each grade were counted. Both sites produced cracked roots, which were counted. A sub-sample of four medium-sized roots was removed from each plot and oven dried (Site-1 on 21 April; Site-2 on 22 April) at 60 °C to calculate dry matter content. The dried root samples were then collected for tissue analysis (nitrogen and potassium). Data from the two sites were analysed separately by REML, using the GENSTAT™ 5 statistical software package.

Table 1: Initial soil characteristics at the trial sites.

Analysis	Units	Site-1	Site-2
pH		5.5	6.2
Olsen P	ug/ml	23	80
Potassium[1]	me/100g	0.53	1.70
Calcium	me/100g	14	19.5
Magnesium	me/100g	2.94	3.41
Sodium	me/100g	0.14	0.15
Cation exchange capacity	me/100g	28.2	34.5
Base saturation	%	62	72
Volume weight	g/ml	0.85	0.82
K/Mg ratio		0.2	0.5
Organic matter	%	10.1	11.1
Available nitrogen	kg/ha	129	55
Total nitrogen	%	0.5	0.44
Reserve potassium	me/100g	0.33	0.44

[1] Equivalent to 264 kg/ha (Site-1) and 818 kg/ha (Site-2), by calculation.

4 RESULTS AND DISCUSSION

4.1 Season

The two trial sites were not irrigated and received 470 mm of rain over the growing season (20 November to 13 April), as measured at Dargaville (National Institute of Water and Atmospheric Research Ltd 1999). The long term recorded average rainfall (since 1943) for the six months, November to April inclusive, is 496 mm. However, the same months in the 1998/99 season received 598 mm. The distribution of rainfall within the season was particularly abnormal as January had the third highest rainfall on record since 1943, while February had the third lowest. The trials were affected by heavy rains during January when they received 198 mm, over four times the January average rainfall (48 mm for the previous 10 years on record). The rainfall was concentrated (163 mm) over a 10 day period with heavy falls (Figure 1) on 16 January (40 mm) and 21 January (73.2 mm). The sweetpotato crop suffered water stress during the January period, as evidenced by root rots in some more mature crops in the district. Site-2 was particularly affected by surface water flow, as demonstrated by the silt film on leaves at the date of leaf sampling (6 February) and the lower yield. Because these trial results are based on one abnormal season and the crop underwent some physiological stress through flooding, the response to fertilizer may not be representative.

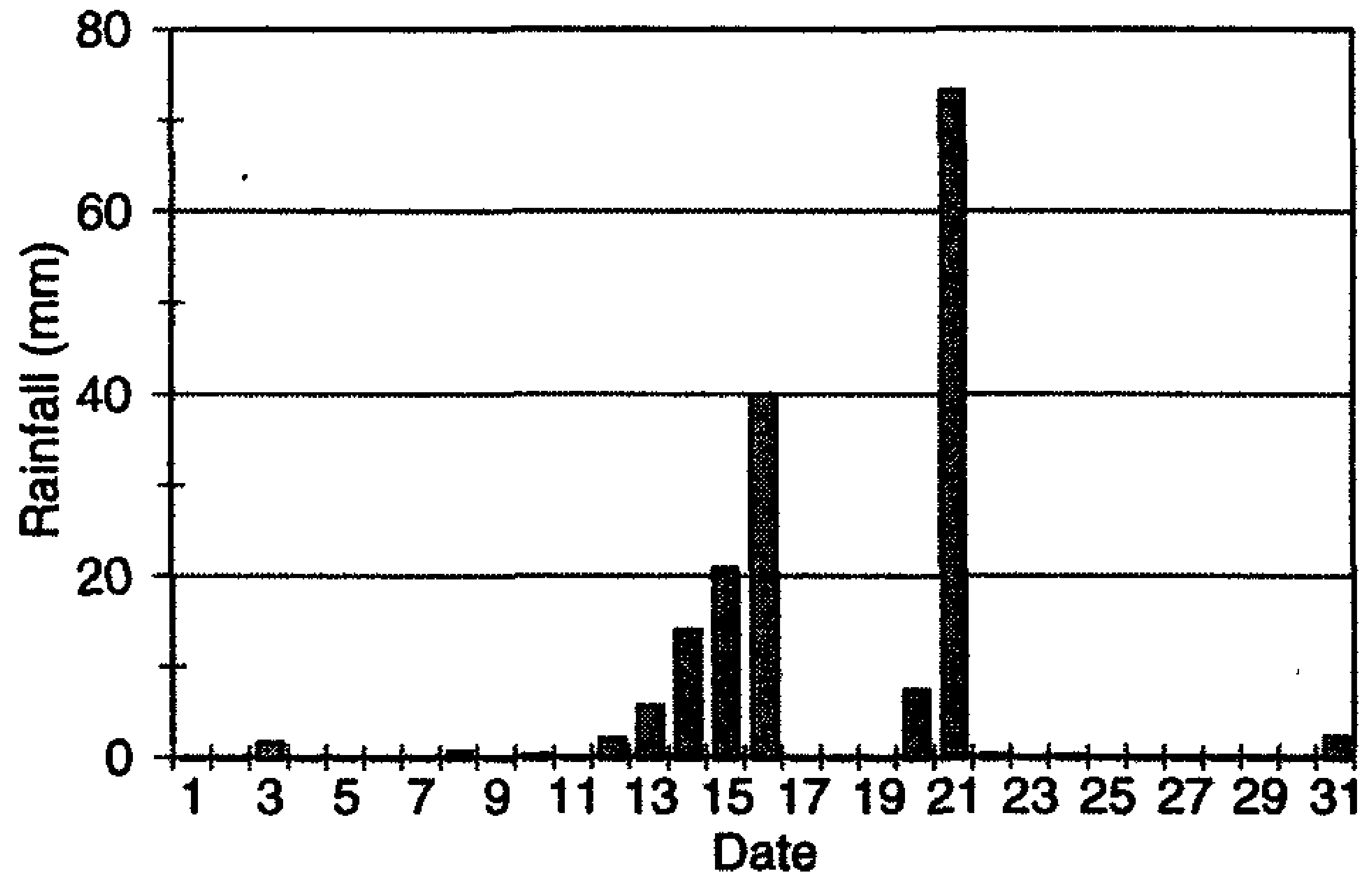

Figure 1: Rainfall (mm) at Dargaville during January 1999 (Source:NIWA).

However, the results from Site-2 (average total yield 18.5 t/ha) generally followed the trends of Site-1 (average total yield 29.9 t/ha). Average plant survival rates were 99% (Site-1) and 95% (Site-2). For results dependent on plant number, the data were analysed with plant numbers as a covariate to remove the effect of lower plot populations. There were no significant differences in the proportion of roots that were saleable for either site, so total yield is reported. There were generally no interactions between nitrogen and potassium; any observable effects of increasing either nutrient were the same at all levels of the other nutrient.

4.2 Nitrogen

Applications of nitrogen gave a significant linear trend (Table 2) at Site-1, with total yield increasing by 1.1 t/ha for every addition of 50 kg/ha of nitrogen ($P = 0.014$). Applications of nitrogen had little effect on root dry matter content (Table 3). The level of nitrogen in dried leaf samples (% N) 79 days after transplanting (DAT) showed a linear trend, with an increase of 0.28% N for every addition of 50 kg/ha of nitrogen ($P < 0.001$). The results from Site-2 also showed this relationship, with a linear trend showing an increase of 0.27% N in dried leaves 73 DAT for every addition of 50 kg/ha of nitrogen ($P = 0.004$). The percent leaf nitrogen was adequate (4.2-5.0%) for all levels of applied nitrogen at Site-1, but was generally low at Site-2, especially when under treatments of 0 or 25 kg/ha of applied nitrogen (O'Sullivan et al. 1997). The initial soil nitrogen levels at Site-2 were lower than those at Site-1 (Table 1), but the percent leaf nitrogen responded to additions of fertilizer. The level of nitrogen in dried storage root tissue at harvest for Site-1 showed a linear trend, with an increase of 0.1% N for every addition of 50 kg/ha of nitrogen ($P < 0.001$). At both sites, the level of applied nitrogen had a significant effect on the level of potassium in dried storage root tissue. At Site-1 each addition of 50 kg/ha of nitrogen gave an increase of 0.07% K, but at Site-2 the same increases of nitrogen gave decreases of 0.09% K ($P = 0.032$ and 0.003 respectively). Neither site showed yield suppression from high nitrogen levels.

The average harvested root yield for Site-1 was 29.9 t/ha with a dry matter content of 30.4% and a root nitrogen content of 0.645% (on a dry weight basis). Therefore, 58.6 kg/ha of nitrogen was contained in this yield of harvested roots and potentially removed from the field (1.96 g N/kg root fresh weight). For Site-2, the average fresh yield (18.5 t/ha), dry matter content (29.1%) and nitrogen content in dried tissue (0.538%) gave 29.0 kg/ha of nitrogen in this yield of harvested roots (1.57g N/kg root fresh weight). The amounts of nitrogen removed in these yields of Owairaka Red roots are similar to those reported (2.2 g N/kg root fresh weight) for sweetpotato in general (O'Sullivan et al. 1997). So while Owairaka Red does not have a high requirement for nitrogen, additional nitrogen may be beneficial for sustainable production.

Table 2: Significant linear responses from applying nitrogen (N) and potassium (K) fertilizer.

Site	Fertilizer	Response	P-value
1	N: for each addition of 50 kg/ha	Total yield: increase of 1.1 t/ha	0.014
1	K: for each addition of 50 kg/ha	Root dry matter: decrease of 0.24%	0.011
1	N: for each addition of 50 kg/ha	Dried leaf %N: increase of 0.28%	<0.001
1	N: for each addition of 50 kg/ha	Dried root %N: increase of 0.1%	<0.001
1	N: for each addition of 50 kg/ha	Dried root %K: increase of 0.07%	0.032
2	K: for each addition of 50 kg/ha	Dried root %K: increase of 0.018%	0.008
2	N: for each addition of 50 kg/ha	Dried leaf %N: increase of 0.27%	0.004
2	N: for each addition of 50 kg/ha	Dried root %K: decrease of 0.09%	0.003

Table 3: Response of the sweetpotato cultivar Owairaka Red to different levels of applied nitrogen (N) (means averaged over potassium (K) rates).

Site	Applied nitrogen (kg/ha)	Total root yield(t/ha)	Root dry matter content (%)	Leaf N content (%)[1]	Leaf K content (%)[1]	Root N content (%)[1]	Root K content (%)[1]
1	0	29.2	31.2	4.7	2.6	0.56	1.36
	25	29.0	30.4	4.9	2.7	0.60	1.32
	50	30.3	29.5	5.3	2.8	0.68	1.43
	100	31.1	30.3	5.3	2.7	0.74	1.48
	$LSD_{0.95}$	2.82	1.09	0.26	0.14	0.085	0.14
	P-value	0.094	0.022	<0.001	0.032	<0.001	0.10
2	0	18.1	28.6	3.8	2.8	0.52	1.59
	25	18.3	29.1	3.9	2.7	0.54	1.59
	50	18.6	29.3	4.1	2.9	0.52	1.51
	100	19.1	29.3	4.3	2.8	0.57	1.42
	$LSD_{0.95}$	2.80	1.19	0.22	0.16	0.039	0.13
	P-value	0.54	0.51	0.027	0.48	0.027	0.041

[1] Expressed on a dry weight basis.

4.3 Potassium

Applications of potassium fertilizer had little effect on total yield (Table 4). Even at Site-1, which had a lower initial soil potassium content and lower leaf %K relative to Site-2, there was little yield benefit in applying potassium fertilizer. The leaf %K at Site-1 was low (<2.8%), but yields did not respond to added potasium, possibly due to the season (O'Sullivan et al. 1997).

The dry matter content of harvested roots at Site-1 showed a linear trend, with a decrease in percent dry matter of 0.24% for every addition of 50 kg/ha of potassium ($P = 0.011$). The level of potassium in dried storage root tissue at Site-2 showed a linear trend, with an increase of 0.018% K for every addition of 50 kg/ha of potassium ($P = 0.008$). There were no significant differences in the level of potassium in dried leaf samples with increasing potassium application at either site (P = 0.55, 0.25 respectively). The leaf % K was in the adequate range (2.8-6.0%) for all levels of applied potassium for Site-2, but was generally low at Site-1, which had low initial soil potassium levels (O'Sullivan et al. 1997).

The average harvested root yield for Site-1 was 29.9 t/ha with a dry matter content of 30.4% and a root potassium content of 1.395% (on a dry weight basis), so 126.8 kg/ha of potassium was contained in this yield of harvested roots and potentially removed from the field (4.2 g K/kg root fresh weight). For Site-2, the average fresh yield (18.5 t/ha), dry matter content (29.1%) and potassium content in dried tissue (1.528%) gave 82.3 kg/ha of potassium in this yield of harvested roots (4.4 g K/kg root fresh weight). The amounts of potassium removed in these yields of Owairaka Red roots are slightly less than those reported (5.0 g K/kg root fresh weight) for sweetpotato in general (O'Sullivan et al. 1997). Although this trial showed no yield response to additions of potassium, large amounts were removed in the harvested crop.

Table 4: Response of the sweetpotato cultivar Owairaka Red to different levels of applied potassium (K) (means averaged over nitrogen (N) rates).

Site	Applied potassium (kg/ha)	Total root yield (t/ha)	Root dry matter content (%)	Leaf N content (%)[1]	Leaf K content (%)[1]	Root N content (%)[1]	Root K content (%)[1]
1	0	30.0	30.9	5.1	2.7	0.66	1.36
	100	28.6	31.3	5.0	2.6	0.64	1.27
	200	29.7	30.1	4.9	2.7	0.61	1.38
	400	31.2	29.3	5.2	2.7	0.67	1.57
	$LSD_{0.95}$	2.82	1.15	0.27	0.15	0.073	0.14
	P-value	0.15	0.007	<0.001	0.55	0.075	0.004
2	0	17.5	29.0	4.1	2.8	0.53	1.50
	100	19.1	29.6	4.0	2.7	0.53	1.47
	200	18.9	28.8	4.2	2.9	0.55	1.52
	400	18.6	28.9	4.0	2.8	0.55	1.62
	$LSD_{0.95}$	2.85	1.19	0.23	0.16	0.041	0.14
	P-value	0.44	0.56	0.061	0.25	0.31	0.028

[1]Expressed on a dry weight basis.

4.4 Cracking

Cracked roots have been observed at harvests over a number of seasons, without any obvious relationship to nematode infection or water stress. This season, a portion of the harvested roots from both sites showed deep cracks and were graded as unmarketable. Fertilizer appeared to have had some influence on cracking. The proportion of cracked roots was greater with the higher soil nitrogen levels at Site-1 (2.9% of total root number) than at Site-2 (0.5%), but the response pattern was similar.

The numbers of cracked roots at each site were analysed separately using a generalised linear model (McCullagh & Nelder 1989). At Site-1, as the level of applied nitrogen increased so did the degree of cracking ($P = 0.008$), while varying the level of potassium also influenced the number of cracked roots ($P = 0.035$). However, the effects of the two fertilizers on root cracking are not independent ($P = 0.023$). This interaction between the levels of nitrogen and potassium was further examined at each site by testing for symmetry about the diagonal (Table 5). This showed that with high potassium and low nitrogen levels there was less cracking than in the converse situation ($P < 0.001$). Therefore, for any given level of nitrogen, increasing the application of potassium decreased the degree of cracking.

Table 5: The total number of cracked roots under different fertilizer regimes, at each site.

		Site-1					Site-2				
Nitrogen (kg/ha)		0	25	50	100	Total	0	25	50	100	Total
Potassium (kg/ha)	0	6	3	3	5	17	0	0	1	0	1
	100	3	8	9	12	32	2	0	4	1	7
	200	1	1	10	5	17	0	0	1	4	5
	400	2	3	1	10	16	0	1	2	0	3
	Total	12	15	23	32	82	2	1	8	5	16

P-values:			Site-1	Site-2
	Nitrogen	(N)	0.008	0.038
	Potassium	(K)	0.035	0.131
	Interaction	(NxK)	0.023	0.098

4.5 Summary

These fertilizer trial results should be interpreted with care due to the abnormal rainfall in January. There is some evidence that rain affected the trials through surface water flow and waterlogged soil. However, the levels of nitrogen in both leaves and roots responded to additions of nitrogen fertilizer. Total yield showed a significant trend, with a yield increase of 1.1 t/ha for each addition of 50 kg/ha of nitrogen. The highest levels of added nitrogen in these trials did not depress sweetpotato yield. The amount of nitrogen contained in roots at harvest was similar to amounts reported internationally. Applications of potassium had little effect on yield, even when initial soil levels were low. Leaf potassium levels did not respond to additions of potassium fertilizer, but root potassium levels responded positively. Increasing potassium levels lowered the root dry matter content. The levels of potassium in harvested roots were slightly lower than those recorded internationally, but considerable amounts of potassium were still removed at harvest. Finally, the results show that the ratio of

5 ACKNOWLEDGEMENTS

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