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Assessment of seed tuber treatments of New Zealand yam

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1 Executive summary

Plant loss of New Zealand yams (*Oxalis tuberosa*) caused by soil or seed tuber-borne diseases can be very high. Seed tuber treatments are not normally carried out before yams are planted as no fungicides are registered for this use in New Zealand. Fifteen potential fungal pathogens have been identified from tubers from the North and South Island, with seven of them identified as being of major importance (Mike Dance pers. comm.). Two of these diseases occur at planting time and at harvest, while five are found at planting and throughout the growing period of crops.

Two field trials were carried out to test the effects of fungicide treament of seed tubers on crop performance and on soil borne diseases. Sound seed tubers were treated with five fungicide mixtures chosen as likely to be effective against previously recorded potentially pathogenic fungi. A bio-inoculant was also included in the trials.

In one trial at Ashhurst, in the North Island, the experimental treatments did not affect the number of emerged shoots and the average weight of clean tubers. A significant increase in the numbers of thick shoots resulted from one treatment and four treatments increased the proportion of clean harvested tubers.

In the second trial, in Invercargill, one treatment gave a higher number of shoots but although there was variation, no treatments produced significant differences in the aspects being measured.

The trials were carried out in a season with a dry spring and there was minimal effect of diseases on the experimental trials. Therefore, we have been largely unable to determine the efficacy of fungicides and the bio-inoculant during the 2000/01 season.

2 Introduction

Oxalis tuberosa, New Zealand yam, is also known as South American oca. This plant is different from true yam (*Dioscorea* sp.). New Zealand is the only country outside South America where *O. tuberosa* is grown commercially (Martin et al. 1999). Growers of New Zealand yams have their own lines derived from breeding and selection, and some lines have been imported by Crop & Food Research (Martin et al. 1999). Tubers for planting are selected from the previous harvest using varying criteria. Often the seed tubers have been damaged by insects, or have other defects. Small tubers (25-50 mm) often grow as daughter tubers on larger ones, and these are sometimes used as seed tubers if there is a shortage of planting material. Thus the size of seed tubers can be very variable, and the growth from them is often poor. Seed tubers can also rot in the ground, reducing plant populations and hence crop yields.

In the 1999/2000 season, wet conditions were experienced after planting in the Manawatu. Seven plots were assessed for yield and for insect or disease damage. The percentage of rot in the plots varied from 0.9 – 10% (Parmenter et al. 2000). The growing points of tubers seem to be a site of entry for fungi; tuber rots are important after storage.

During the 2000 harvest, fungi were isolated from yams from the South and North Island. A list of the fungi (Table 1) associated with rot in New Zealand yams was the result of this survey (Carpenter et al. 2000). Many tubers in Manawatu and the South Island did not produce any plants (Fig. 1): they disappeared in the wet spring. This was principally associated with infections by blue mould (*Penicillium* sp.) (Fig. 2). Of the tubers which were harvested

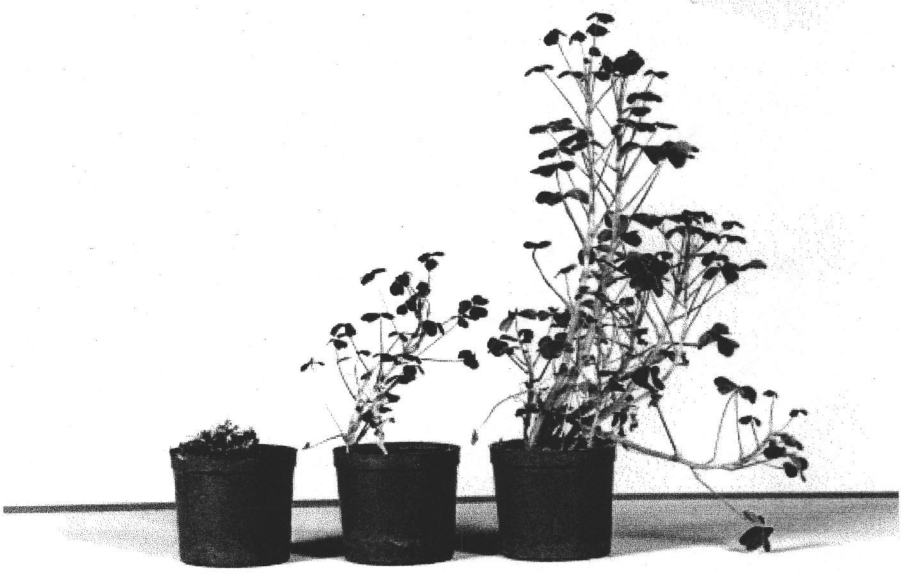

Figure 1: Different growth rate from tubers in the laboratory: heavily infected medium infected and not infected (right) after 3 weeks.

in August 2000, the firm, healthy, light coloured tubers, with purple areas at the growing points were examined for identification of potentially pathogenic fungi. Some fungi develop on tubers shortly after planting, and are associated with poor plant emergence. Some fungi are likely to attack yam tubers during the growing season, and will be on the tubers at planting time and at harvest (Table 1). From December onwards the stems at the base of yam plants sometimes show dark areas, and the plants wilt. The number of affected plants will increase over March and April. The fungi that were isolated from stem lesions are the same as those that were found on the tubers.

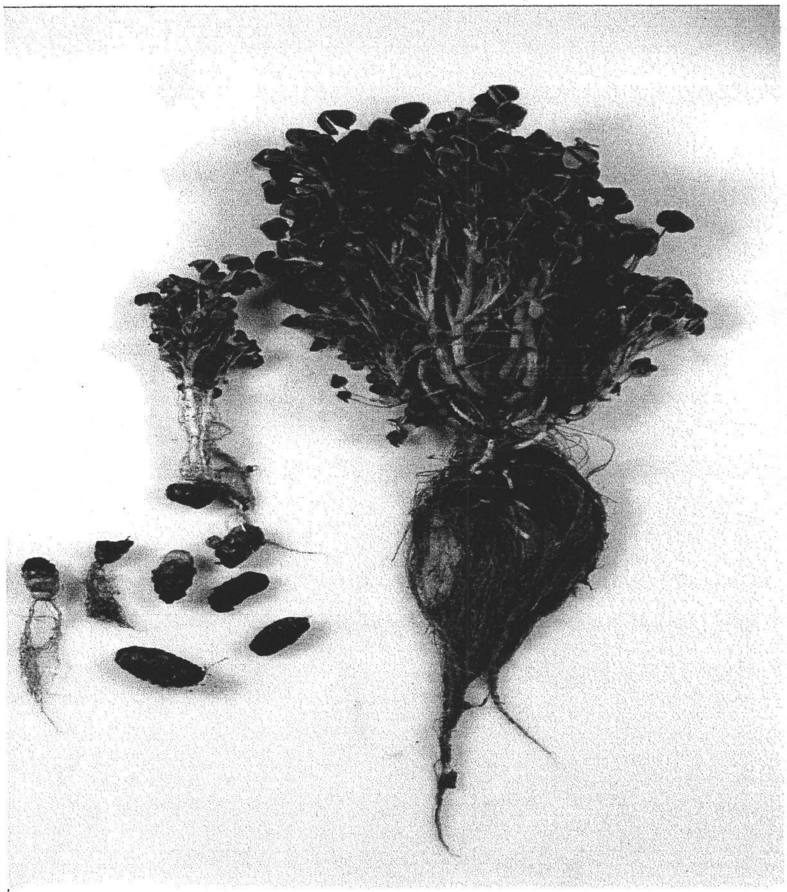

Figure 2: Tubers from the field affected by blue mould. Healthy plants on right.

Fungal pathogens could develop from seed tuber-borne or from soil-borne inoculum (Mike Dance pers. comm.) (Table 1, column 3). *Fusarium* spp. (Fig. 3) are possibly the major cause of poor plant establishment (Martin et al. 1999) (Mike dance pers. comm.) (Table 1, column 4).

Post harvest treatment of New Zealand yam is often not feasible. Freshly harvested tubers are attractive and shiny for buyers so tubers are harvested “on demand” between May and July. Storage above ground gives the tubers a dull colour. Post harvest control of seed tuber-borne diseases requires immediate curing of tubers providing optimum conditions for healing of skin abrasions or insect damage. This post harvest treatment is not usually carried out by growers.

In the present report we outline an investigation of seed tuber treatments for control of yam diseases. By treating the seed tubers we hoped to give them an early growth advantage with less attrition of the plants in spring from fungal diseases. This would possibly improve crop yields.

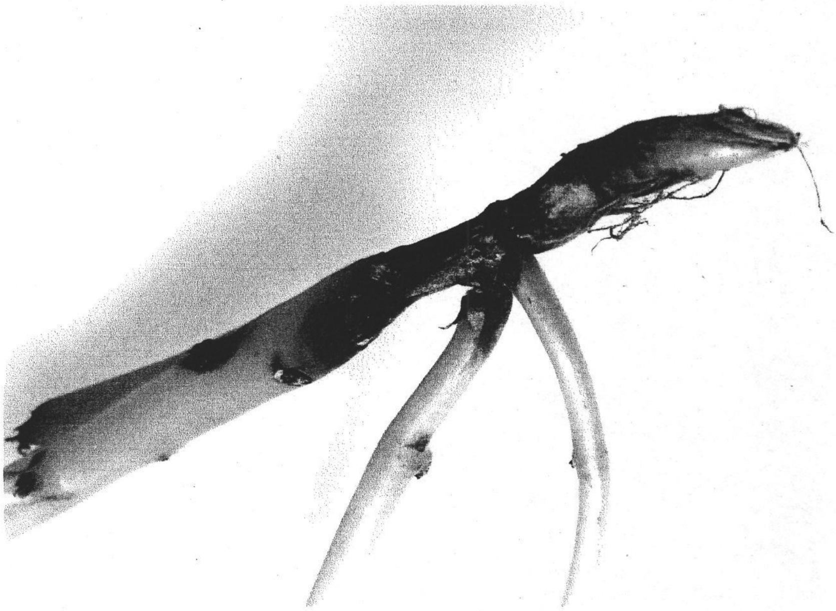

Figure 3: Fusarium spp. in Ashhurst is a common problem on stems in the field from December onwards.

Table 1: Fungi possibly involved in New Zealand yams (tuber and stem) grown in the North and South Island.

	Pathogen	Rot		
		Likely to be of importance	Present at planting and at harvest	Present at planting and during growing season
1	*Botrytis cinerea*	-	-	Yes
2a	*Fusarium avenaceum*	-	-	Yes
2b	*F. culmorum*	Yes	-	Yes
2c	*F. oxysporum*	-	-	Yes
2d	*F. solani*	Yes	-	Yes
2e	*F. graminearum*	Yes	-	Yes
3	*Geothrichum candidum*	-	Yes	-
4	*Mucor* sp.	Yes	Yes	-
5	*Nectria radicicola*	-	-	Yes
6	*Penicillium* sp.	Yes	Yes	-
7	*Phoma exigua*	-	-	Yes
8	*Phytophtora megasperma*	-	-	Yes
9	*Pythium* sp.	Yes	-	Yes
10	*Rhizoctonia* sp.	Yes	-	Yes
11	*Rhizopus stolonifer*	-	Yes	-

Source: Mike Dance

3 Materials and methods

Fungicides were chosen in this trial which have wide spectra of activity against diseases found in yam tubers (Table 2). The fungicides are registered for other uses in New Zealand. A tuber treatment with a bio-inoculant was also tested in this trial, since it is claimed that the product increases the *Trichoderma* activity in the soil which benefits plant growth and vigour. The fungicide, Monceren, was added in the Ashhurst trial at the request of the grower.

Table 2: Fungi suppressed by fungicides and an inoculant and their rates.

Treatment	Active ingredient	Rate
Untreated control		
Vitaflo 200	Carboxin + thiram	25 ml/10 kg tubers
Orthocide 48F + Rizolex	Captan tolclofos-methyl	17.5 ml/10 kg 25 g per 100 kg
Tecto (1 part) + Thiram 80W (3 parts)	Thiabendazole thiram	5.0 ml/litre 120 g per 10 litre
Ridomil Gold EC + Tecto	Metalaxyl-M thiabendazole	0.4 ml/litre 5 ml/litre
Trichopel-R	Trichoderma fungus	1 gram per tuber
Monceren	Pencycuron + imazalil	2 g per kg tuber

Tubers that had been stored at 5°C were collected from the farmer. The tubers were chosen at random but were all of similar size. They were washed and allowed to dry before being dipped for 4 min in the respective chemical solutions, which were agitated throughout the process. Treatments were applied in Ashhurst on 8 November and in Invercargill on 16 November. After treatment, the tubers were dried and graded in lots with each replicate having a similar weight of tubers. They were then stored at 10°C. The tubers treated with Vitaflo and Monceren were dusted by placing the tubers into a plastic bag containing the fungicide powder. They were then shaken.

Tubers were planted at two sites; on silt loam near Ashhurst on 14 November and on light Southland soils in Invercargill on 27 November. Tubers were planted 0.4 m apart, with a row spacing of 0.9 m. The trial was of randomised block design with four replicates. Tubers were covered with soil, and the plot rows were ridged/moulded. Each plot consisted of four guard/observation plants on each side of six plants in one row. The eight guard plants were used for early observation and were dug up while the remaining six plants were harvested in July in Ashhurst.

All eight guard plants were lifted from each plot and the numbers of healthy tubers, emerging shoots (thicker than 5 mm in diameter), and rotted tubers were recorded on 16 January in Ashhurst and on 29 December in the Invercargill.

Wilting symptoms as a result of disease infected stems were recorded in the February in the Ashhurst trial. The remaining plants in each plot were harvested in Ashhurst on 28 June and in Invercargill on 18 July. All yams were washed, graded by size into two categories (25-50 mm and 50 mm and over), and weighed. The number of diseased tubers and tubers with insect damage were recorded.

4 Results

All purple ends of yam sent for pathogen identification in 2000 (Parmenter et al. 2000) yielded common rot pathogens: *Botrytis cinerea, Colletotrichum coccodes, Glomerella cingulata, Penicillium* sp. *Phoma exigua, Alternaria alternata* and *Nectria radicicola* (Fig. 4). These early symptoms of rot caused by colouration to pathogen invasion deteriorated quickly once they had been excised and plated in the laboratory for identification. This is normal for most tissues infected with rot pathogens. The discolouration of the tuber ends seems to be a general response to invasion rather than a symptom of attack by any particular pathogen (Mike Dance pers. comm.).

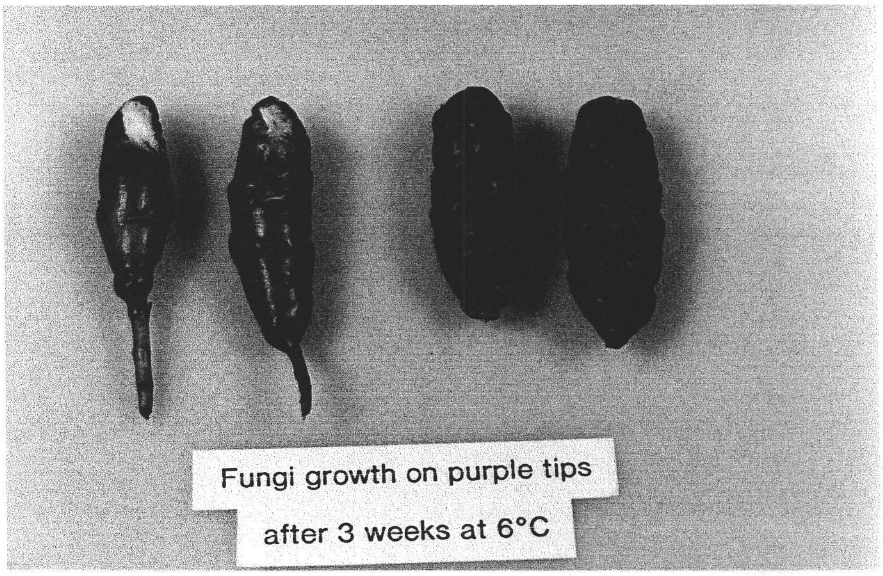

Figure 4: Dark tipped yam tubers with fungal growth kept at 8°C in the laboratory.

When the guard plants in the trial plots were lifted the level of disease was minimal. Samples of affected tubers were sent for identification. Diseased samples from two plots (Tecto + Thiram, and Monceren) in the Ashhurst trial and one sample from the Invercargill trial (Ridomil + Tecto treatment) were the only diseased samples in the trials. These tubers contained the pathogens *Fusarium oxysporum, Nectria radicicola* and *Pythium* sp.

4.1 *Ashhurst trial*

On 16 January the guard plants were assessment for rot and vigour. The only rotted plants were one plant in each of the two treatments, control and Ridomil + Tecto, and two plants in the treatment Tecto + Thiram. To assess vigour, the number of thick shoots emerging above ground, as well as final yields, are recorded for the Ashhurst trial (Table 3).

On 28 February plants were checked for signs of wilting, which is commonly associated with fungal attack on the stems. This symptom was noticed in four plants each of the control and Vitaflo treatments. Plants were harvested on 30 May and the tubers were washed and graded by size and stored at 5°C. In general the yield was very poor and tubers had many knobs (daughter tubers) due to the dry weather conditions over the growing season. Only one tuber in all the treatments showed obvious rot, while most of the damaged tubers showed only slight blemishes including small, unidentified orange coloured skin damage.

Table 3: Ashhurst trial. Early assessment of the mean number of shoots above ground, percentage of thick shoots, total clean yield, % clean tubers, and % large clean tubers per plot.

Treatment	Number of shoots per plot	Percentage of 5 mm shoots and over	Total clean yield per plot	Percentage Clean tubers	Percentage large tubers	Average weight of clean tubers (g)
Control	44.5	37.2	1598.0	69.0	12.5	10.7
Vitaflo	44.3	32.0	1661.0	70.8	20.8	9.3
Orthocide + Rizolex	39.8	45.9	2266.0	82.7 *	12.6	9.9
Tecto + Thiram	38.0	51.6*	2108.0	82.3 *	12.6	9.0
Ridomil + Tecto	41.5	40.1	2200.0	80.1 *	15.3	11.8
Trichopel-R	46.0	35.8	2335.0*	81.8 *	12.6	10.1
Monceren	44.8	38.5	2017.0	75.0	12.1	9.8
LSD (P<0.05; df=18)	7.3	11.0	747.5	8.8	13.3	3.1

* Statistically significant effects on % clean tubers

The experimental treatments did not affect the number of emerged shoots (Table 3). A statistically significant increase (P<0.05) in the number of thick shoots resulted from the Tecto + Thiram treatment as compared to the control. Orthocide + Rizolex also gave a higher percentage than the other treatments.

The number of rotted tubers found at harvest was so small that no definitive conclusions could be made from this trial. All treatments gave higher total yield than the untreated control, but overall no statistically significant differences were found between the treatments. There were no significant differences between treatments in the average weight of clean tubers.

Four of the treatments (Orthocide + Rizolex, Tecto + Thiram, Ridomil + Tecto and Trichopel-R) increased ($P<0.05$) the proportion of clean harvested tubers, compared to the control.

4.2 *Invercargill trial*

Vigour and yield summaries are given in Table 4.

The Orthocide + Rizolex treatment had the lowest number of shoots, 10% less than the next lowest treatment.

There were no statistically significant differences between the treatments in the percentage of thick shoots. The untreated control had the highest percentage of thick shoots. At harvest, all treatments gave greater average clean tuber weight than the untreated control, but the differences were not statistically significant. The Ridomil + Tecto treatment gave the highest average weight per clean tuber, 22% greater than the untreated control. The Trichopel-R treatment gave a smaller proportion of clean tubers than most other treatments. Overall, there was a very high proportion of clean tubers. No differences were ($P<0.05$) found in the total clean weight of the tubers per plot, although there was a considerable range between treatments. For example, the Vitaflo treatment yielded 42.1% greater clean harvest than the Trichopel-R treatment. Vitaflo was relatively more effective in the Invercargill trial than in the Ashhurst while Trichopel was more effective in Ashhurst than in Invercargill, relative to the other treatments.

Table 4: Invercargill trial of seed tuber fungicide treatments: with early assessment of the mean number of the total number of shoots emerged, percentage of thick shoots, mean clean tuber weight (g), percentage of clean tubers, percentage tubers with 30% rot and percentage of all rots.

Treatment	Total[1] number of shoots	Percentage of thick shoots >5 mm of all	Percentage of clean tubers	Mean clean tuber weight	Percentage of tubers with more than 30% rot	Percentage of tubers with any rot	Total clean weight per plot
Control	111.5	39.0	88.3	15.9	4.1	6.1	3009.0
Vitaflo	115.0	35.7	89.1	17.6	3.0	8.2	4031.0
Orthocide + Rizolex	95.5	36.1	90.0	18.1	1.9	5.4	3670.0
Tecto + Thiram	123.5	32.4	88.7	17.4	1.6	4.9	3569.0
Ridomil + Tecto	144.8[2]	29.3	85.7	19.4	1.5	7.2	3916.0
Trichopel-R	106.5	31.5	79.9	16.9	6.7	11.4	2837.0
LSD ($P<0.05$; df= 18)	24.8	11.1	9.4	3.6	4.4	6.4	1194.0

[1]Total number of shoots above ground
[2]The Ridomil + Tecto treatment had significantly more shoots than all treatments except Tecto + Thiram.

The treatments Orthocide + Rizolex, Tecto + Thiram and Ridomil + Tecto had the lowest percentages of all tubers (Table 4) more than 30% rotted, but no treatment was significantly different from the untreated control.

5 Discussion

The very mixed nature of the pathogen suite in New Zealand yam tubers makes the management of soil borne or tuber borne disease difficult. Adequate control of these diseases may best be achieved by selection of healthy seed tubers, appropriate crop rotation, and possibly selection of varieties that are resistant to disease.

The very dry conditions at the Ashhurst trial site were reflected in the low yield achieved, and the yams in this trial did not benefit from the use of fungicides. Trichopel also requires adequate moisture in the soil to enable effective colonization with the beneficial fungus (New Zealand Agrichemical Manual 2000).

6 Acknowledgements

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Dr Mike Dance (AgriQuality New Zealand) gave advice on the fungicides to be tested and identified the fungi. Warren Osborne (Ashhurst), Clynt Smythe of Almadale partnership (Kimbolton) and Blair Spain (Invercargill) supplied us with the tubers and gave us access to trial plots. Alieu Sartie gave technical assistance.

7 References

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