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Control of Phytophthora root rot in spinach

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1 Executive summary

A field trial was established on a commercial property to evaluate the effects of three biological products (Trichoflow, Superzyme and BQ Mulch), three cultural practices (raised bed alone, herbicide and raised bed + BQ Mulch) and RidomilG (a soil fungicide) on Phytophthora root rot in spinach.

Superzyme and raised bed alone treatments significantly reduced the root rot compared to the untreated plants. Superzyme and raised bed alone treatments also had significantly less root rot than the other treatments except the herbicide treatment. RidomilG increased the severity of rot compared to the untreated control although the difference was not significant. There were no significant differences in plant weight between plants in all of the treatments. No symptoms of phytotoxicity were observed on any of the treated plants.

On the basis of these results, we recommend that Superzyme or raised bed alone can be used to control Phytophthora root rot on spinach. Further trials are needed to confirm the results in different seasons and locations.

2 Introduction

In May 2002 root rots appeared to be a major problem on spinach especially in low lying areas in Pukekohe. Close examination of these rots showed that species of *Phytophthora, Pythium* and *Fusarium* were involved. Affected plants became stunted and the leaves turned yellow to brown (Fig. 1).

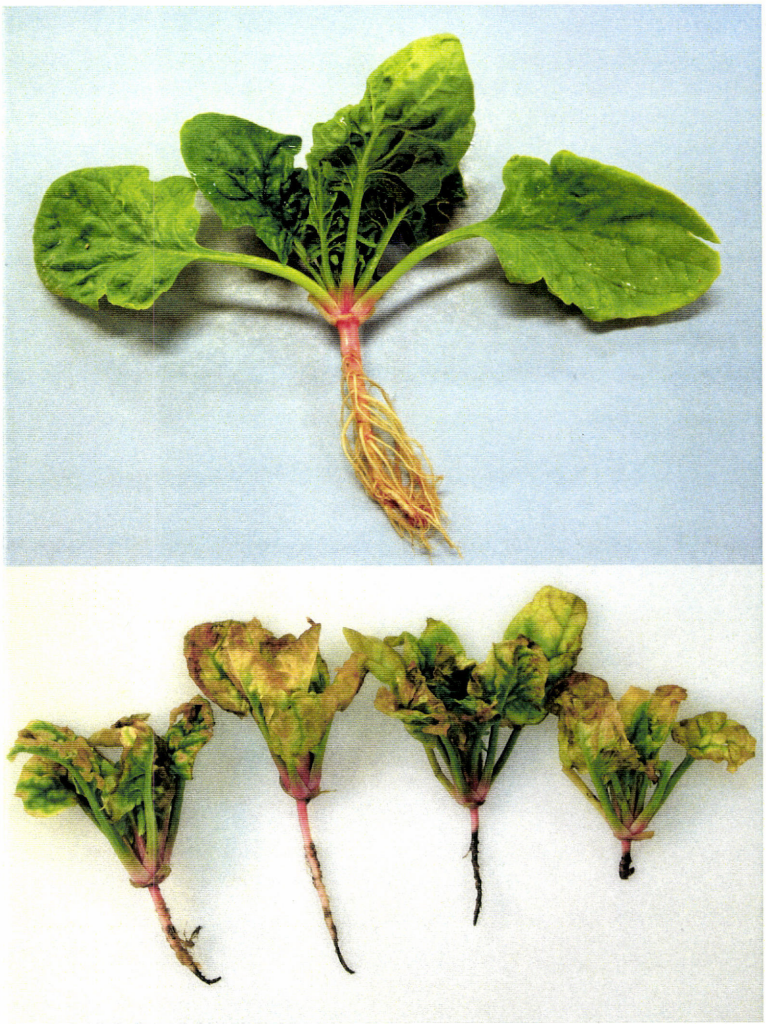

Figure 1: Phytophthora root rot on spinach: above – healthy plant; below – different degrees of root rot on root systems.

The tap root became dark brown to black and there were no feeder roots. A preliminary survey showed that most plants that were grown in low lying areas were affected. Growers were concerned about the effects of the disease and requested an investigation be undertaken.

Our aim is to develop an integrated disease management programme for Phytophthora root rot in spinach by:

- reviewing articles on Phytophthora root rot in spinach to identify the disease and management techniques, and
- evaluating biological products, fungicide and cultural practices for their efficacy for control of Phytophthora root rot.

3 Materials and methods

3.1 Literature survey

Literature searches were carried out using scientific databases. In particular, we accessed CAB abstracts and Current Contents and looked for all relevant publications on spinach.

3.2 Field trial

A field trial was carried out in a commercial property in Levin (Woodhaven Gardens). The land was ploughed and rotary hoed. A pre-emergence herbicide was applied to all plots, except the two untreated controls (Treatments 5 and 7, Table 1), two days after sowing the spinach.

The trial area was made up of 6 blocks, each 40 m wide and 10 m long. There was a 2 m gap between blocks. Each block consisted of 8 randomised plots that were each 2.5 m wide and 10 m long. The plots were made up of four planted rows spaced 0.2 m apart and 10 m in length. A guard plot of the same dimensions as above separated each treatment plot. There was a gap of 1.9 m between the rows of the adjacent guard and treatment plots. Three biological products, three cultural practices and RidomilG fungicide (Table 1) were applied as below:-

Table 1: Treatments and rates for control of Phytophthora root rot on spinach.

Treatment	Rate	
1. RidomilG	0.13 ml/m^2	(=1.3 l/ha)
2. BQ Mulch	0.5 g/m^2	(=5 kg/ha)
3. Trichoflow (*Trichoderma* sp)	0.1 g/m^2	(=1 kg/ha)
4. Superzyme	0.2 g/m^2	(=2 kg/ha)
5. Untreated Control	–	
6. Herbicide (Lasso and Flagflow)	0.3 ml/m^2	(=3l/ha)
7. Raised bed alone	–	
8. Raised bed + BQ Mulch	0.5 g/m^2	(=5 kg/ha)

- RidomilG was applied to the soil once only at planting.
- BQ Mulch seeds were sown and grown for approximately 60 days, rotary hoed into the soil, then left to decompose for about 60 days before the spinach was sown.
- Trichoflow was applied by drenching the soil using a knapsack sprayer then incorporated using a power harrow. This was done before the spinach was sown. A second application was made to the soil one month later.

- Superzyme (contains *Trichderma* spp, *Bacillus subtillus* and *Pseudomonas putida*) was applied by drenching the soil using a knapsack sprayer then incorporating it into the soil using a power harrow. This was done before the spinach was sown. A second application was made to the soil one month later.
- Untreated control. No treatment or applications made to the soil. No pre-emergence herbicide was applied to the soil.
- Herbicide treatment. A pre-emergence herbicide was applied after spinach had been sown.
- Raised bed alone (no pre-emergence herbicide). A drainage channel on each side of the plot was made by digging the soil to a depth of about 0.3 m and mounding the soil up on the plot. This gave the impression that the beds were higher than the other unraised or 'normal' beds. Spinach was grown in the beds.
- Raised Bed + BQ Mulch. This practice followed the methods of treatment as described above. Spinach was grown on a bed prepared as described above.

Soil samples were taken before and after application of these treatments to measure changes in soil pH.

The trial design was a randomised complete block design with 6 replications (blocks). Each block consisted of 8 plots, each with a randomly allocated treatment (see Table 1).

At maturity (about 70 days after sowing) plants were harvested from each plot at 1 m intervals starting from a random point along the row. The weight of each plant was recorded. Two rows per plot with 15 plants per row (a total of 30 plants) were harvested. The root systems of all plants were carefully excavated and brought to the laboratory. The length of the diseased portion (showing black discoloration) of each root system was measured and a percentage rotted area estimated.

Mean plant weight and percentage of plant root system affected by rot were compared between treatments using analysis of variance. The percentage values were log-transformed to equalise variances before analysis.

4 Results

4.1 Literature survey

The literature search revealed few publications on Phytophthora root rot of spinach. Several *Phytophthora* species, including *P. megasperma* and *P. cryptogea*, have been reported to cause root rot of spinach in USA (Farr et al. 1989; Sumner 2003). A few species of *Fusarium* (Larsson & Gerardson 1992) and *Pythium rostratum* (Pennycook 1989) were also reported to cause root rot in New Zealand. To date only two publications reported on disease control measures: Sumner et al. (1976) and Larsson & Gerhardson (1992).

4.2 Field trial

Superzyme and raised bed alone treatments significantly reduced the percentage of root rot compared to the untreated plants (Table 2). Superzyme and raised bed alone treatments also had significantly less rot than plants in other treatments, except those in the herbicide treatment. Herbicide-treated plots had less root rot than the untreated control, but not significantly so (P>0.10). The other treatments did not reduce root rot. RidomilG increased rot severity compared to the untreated control although not significantly. No symptoms of phytotoxicity were observed on any of the treated plants. There were no significant differences in plant weight between all treatments.

Table 2: Effect of biological products, cultural practices and Ridomil on plant weight and percentage root diseased.

Treatment		Weight per plant	Percent root diseased[1]	Log10 (percent diseased)[2]
1.	RidomilG	24.65	1.16	0.06
2.	BQ Mulch	25.86	0.74	-0.13
3.	Trichoflow	25.33	0.51	-0.29
4.	Superzyme	26.03	0.04	-1.40
5.	Untreated control	30.29	0.51	-0.29
6.	Herbicide	30.66	0.15	-0.82
7.	Raised bed alone	26.92	0.06	-1.22
8.	Raised bed+BQ Mulch	31.59	0.33	-0.48
Treatments		P=0.15	P=0.073	
LSD (P=0.05; df=32)		5.79		0.84

[1]Means from log-transformed data converted back to original scale.

[2]Analysis performed on log scale – use these for LSD comparisons.

5 Discussion

A literature search revealed little information on the control of Phytophthora root rot. Overseas, soil fumigation with methyl bromide (Sumner et al. 1976) and dazomet (Larsson & Gerhardson 1992) has been shown to reduce the incidence of root rot. Consumers around the world are demanding fewer chemical inputs during food production so the spinach growers requested that we evaluated a range of biological products and cultural practices for the control of root rot.

In this trial Superzyme, which consists of three biocontrol agents, significantly reduced root rot caused by *Phytophthora*. Superzyme was also shown to be the best among four biocontrol agents tested for the control of pink rot on potatoes (caused by *Phytophthora erythroseptica*) (Tate et al. 2002). It is interesting to note that the percentage of root systems affected by rot

following the application of RidomilG, a soil fungicide, was higher than in the untreated control although the difference was not statistically significant. The reasons for this difference need further investigation.

Environmental factors like water-logged soil and differences in soil nutrient status may also contribute to root rot (Sumner et al. 1976). We observed that spinach plants that grew in low-lying areas had more root rot and stunted plants than plants elsewhere. In this trial we found that plants that grew on a raised bed alone, to improve drainage, had less root rot than plants in the untreated control. These results indicate that spinach plants should not be grown in low-lying areas.

However, there was no significant increase in plant weight in plants grown in raised beds and those treated with Superzyme perhaps because of soil nutrient deficiencies, wet soil, and cold temperatures when the trial was established.

6 Recommendation

1. Superzyme or raised bed alone can be used to control Phytophthora root rot.
2. Further tests of the above two treatments in different seasons and locations are needed to confirm the results.

7 Acknowledgement

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