EVALUATION OF BENZIMIDAZOLES FOR CLUBROOT CONTROL IN TRANSPLANTED CABBAGES

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Summary

In a series of cabbage trial plantings over two seasons at Levin and Ohakune the best benomyl treatment for transplant protection against clubroot (*Plasmodiophora brassicae*) was a 0.05% drench at 200 ml per planting hole. Equivalent doses of carbendazim or thiophanate-methyl gave similar results to benomyl. Higher doses of benomyl, though more effective in suppressing clubroot, were phytotoxic and did not increase yields. Slurry root dips gave less consistent results than drenches.

INTRODUCTION

Until recently, chemical protection of brassica transplants against clubroot in New Zealand was possible with quintozone or mercury (mercurous or mercuric chloride) fungicides following work overseas by Walker *et al* (1944), Gallegly and Bishop (1955) and in New Zealand by Brandenburg (1962) and Watson (1965). The withdrawal of all three fungicides by the New Zealand Agricultural Chemicals Board on environmental grounds left growers with no satisfactory chemical protection for transplanted cabbages, cauliflowers or brussels sprouts.

Overseas, evaluation of new fungicides against *P. brassicae* by Jacobsen and Williams (1969, 1970), Vanachter *et al* (1971), van Assche and Vanachter (1970), Buczacki (1973, 1976a, 1976b) and others have all demonstrated promising control by benzimidazole fungicides, particularly benomyl.

The urgent need for a replacement chemical treatment in New Zealand prompted research aimed at developing an effective benzimidazole transplanting treatment for cabbages. A summary of the results obtained has been published elsewhere (Tate 1977). Results for a similar treatment currently under evaluation for cauliflowers and brussels sprouts will be published at a later date.

METHOD

Cabbage trials were conducted at different times during two years at Levin on Levin silt loam or at Ohakune on light volcanic loam. Cultivars used were selections of 'Golden Acre' or 'Green Acre', and in all but one trial every planting hole was inoculated with 20 g of a mixture of macerated roots from infected plants and peat, to ensure all plants were equally exposed to abundant inoculum. Trials were replicated 4-6 times in randomised blocks, with 24 or 30 recorded plants per plot at a spacing of 0.5 x 0.5 m. Transplants were raised free of clubroot disease in steam sterilised soil in seedling trays and treated with fungicide or water drenches or slurries during hand planting, after first shaking the roots free of most of their soil. Fertilisers,

Proc. 30th N.Z. Weed and Pest Control Conf.

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weed, disease and pest control were uniformly applied as required to the trials, and irrigation was used where necessary to ensure the wet planting conditions necessary for root infection. Crop locality, planting and harvest dates, crop duration and other details are listed in Table 1.

TABLE 1: Trial details

Trial No.	Locality	Planting Date	Harvest Date	Duration (weeks)	Plants inoculated	Trial irrigated
1	Levin	29.10.75	15-27.1.76	11-13	+	+
2	Levin	27.11.75	21.1-9.2.76	8-10	+	+
3	Ohakune	12.2.76	28.4-5.5.76	10-11		+
4	Levin	5.10.76	30.11-6.12.76	8-9	+	+
5	Levin	12.10.76	7.12-13.12.76	8-9	+	

Treatment effects were measured using Watson's (1965) Root Disease grades and saleable head weight (kg). All root systems were rated for clubbing at time of cutting or rejection of head. Fungicides used included the benzimidazoles benomyl 50% WP, carbendazim 50% WP and thiophanate-methyl 80% WP. Concentrations evaluated, applied as drenches or slurries, are listed in Tables 2 and 3.

Slurry preparation was as follows: 10 g methyl cellulose was mixed into 750 ml water and 300 g perlite into 1 litre water in separate containers and left overnight. Next day shortly before use, the fungicide was mixed well in 250 mls water and this mixed with the hydrated methyl cellulose. This was then added to the perlite suspension to prepare 2 litres of fungicidal slurry. Frequent mixing was required while dipping plant roots to prevent the ingredients from settling out. Freshly prepared fungicidal suspensions (200 ml) were poured into the planting holes immediately before closing the soil around the seedlings. Control plots received 200 mls of water per plant.

RESULTS

Phytotoxicity was caused by benomyl treatments, being severe at high rates but tolerable at low rates. Symptoms lasted for 4-6 weeks and included foliage stunting, interveinal chlorotic mottling and leaf-margin chlorosis. Phytotoxicity was not observed in carbendazim or thiophanate-methyl treated plants. Observations indicated that benomyl drenches retarded growth in the first month while untreated plants grew vigorously. However, within 4-6 weeks untreated plants were wilting from the effects of clubroot while benomyl-treated plants were growing strongly.

Benomyl drenches at 0.13% gave the greatest reduction in clubroot but phytotoxicity was severe (Table 2). At 0.05% clubbing was satisfactorily reduced and phytotoxic effects only slight, while at 0.03%, clubbing was severe enough to stunt the plants. Carbendazim or thiophanate-methyl drenches at 0.05% gave similar results to benomyl. Benomyl slurries at high rates were phytotoxic and at low rates did not reduce clubbing sufficiently in all trials. Plant to plant variation in degree of clubbing was much higher for slurry-treated plots than for drench-treated plots.

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TABLE 2: Effect of transplanting treatments on clubroot of cabbages

Fungicide Treatment	Strength g/100 ml	Clubroot severity ¹ at harvest				
		Trial number				
		1	2	3	4	5
benomyl drench ²	0.13 ³	1.6 f	1.0 c	0.6 b	—	—
	0.09	2.1 ef	0.9 c	0.6 b	—	—
	0.05	2.4 de	0.7 c	0.6 b	2.1 c	0.0 b
	0.03	—	—	—	3.4 b	—
benomyl slurry ⁴	1.00 ³	3.0 bc	—	—	—	—
	0.50 ³	2.8 cd	—	—	—	—
	0.25	3.0 bc	2.3 b	—	—	—
	0.10	3.5 b	2.6 b	—	—	—
thiophanate-) methyl drench)	0.05	—	—	—	2.3 c	—
carbendazim) drench)	0.05	—	—	—	1.9 c	—
water drench	—	4.3 a	4.3 a	2.2 a	5.0 a	5.0 a

¹ Average root score per plot. 0 = healthy roots. 5 = root system completely clubbed.

² 200 mls of suspension drenched into planting hole at transplanting.

³ Severe phytotoxic effects observed.

⁴ Transplant roots dipped into fungicidal slurry-mix before planting.

Generally, mean root scores of less than 3.0 were accompanied by normal plot yields. Benomyl drenches at 0.05% resulted in yields not significantly different from those obtained at higher strengths (Table 3). Carbendazim or thiophanate-methyl drenches gave similar results to benomyl. In trial 3, yield was not increased by a 0.05% drench, and was reduced by a 0.13% drench. Benomyl slurry treatments did not consistently increase yields. Carbendazim, thiophanate-methyl and benomyl drenches at 0.05% all gave satisfactory yields which were not increased by higher strengths of benomyl.

An additional benefit observed from the use of the benomyl drenches in trial 5 was the complete suppression of ring spot disease caused by *Mycosphaerella brassicicola*, for the first month of growth.

DISCUSSION AND CONCLUSION

The greatest clubroot control generally resulted from the 0.13% benomyl drench, but this was not accompanied by higher yields, which were quite adequate at the 0.05% rate. At this lower concentration, clubbing of peripheral roots could be quite extensive (score of up to 2.5) but was apparently tolerated by the plants. Since clubroot control and yields were similar for 0.05% carbendazim or thiophanate-methyl drenches, all three can be recommended as a drench treatment for cabbages. Application of this treatment to cauliflowers or brussels sprouts is not recommended at this stage because of the unknown effect of peripheral root clubbing of these plants on yields. According to Anderson *et al* (1976), cauliflowers may not tolerate clubbing to

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TABLE 3: Effect of transplanting treatments on cabbage yield in clubroot infested soil

Fungicide Treatment	Strength g/100 ml	Saleable yield per plot ¹ (kg)				
		Trial number				
		1	2	3	4	5
benomyl drench	0.13	37.3 a	26.8 a	23.8 b	—	—
	0.09	33.6 ab	28.9 a	34.8 a	—	—
	0.05	39.2 a	31.2 a	36.2 a	27.2 a	28.9 a
	0.03	—	—	—	19.8 b	—
benomyl slurry	1.00	19.4 c	—	—	—	—
	0.50	19.7 c	—	—	—	—
	0.25	23.7 bc	25.0 a	—	—	—
	0.10	16.5 c	25.7 a	—	—	—
thiophanate- methyl drench)	0.05	—	—	—	26.0 a	—
carbendazim drench)	0.05	—	—	—	27.7 a	—
water drench	—	13.4 c	12.9 b	36.5 a	1.2 a	5.5 b

¹ Saleable yield from 24 to 30 plants per plot.

the same degree as cabbages. Benzimidazole slurry treatments are not recommended due to the inconsistent results obtained.

Phytotoxicity symptoms as noted in these trials were also reported by Reyes (1975) who noted differing sensitivities by different cabbage, cauliflower and brussels sprouts cultivars to benomyl-amended soil. Though a growth check occurred at the 0.05% concentration in our trials, this was not considered to be serious.

Success of the drench treatment requires that all soil in contact with the transplant is drenched. If the plant is set too deeply untreated soil is closed about the hypocotyl and clubbing may occur there. Mechanisation of treatment using mechanical planters equipped for watering each transplant is possible though it has not been evaluated. The fungicide suspension would be added to the water tank and the mechanism set to deliver 200 ml to obtain the correct fungicidal dose of 0.1 g per plant. A potential problem with mechanical planters could be the escape of part of each fungicidal dose into the continuously opened planting furrow between plants. In our hand-planted trials each plant received the full 0.1 g dose. A lower volume would mean a lower dose of fungicide per plant which might not give adequate results.

In trials 3 and 5 benomyl drenches appeared to give complete or almost complete clubroot suppression. This was partly due to the retarding effects of cool soil temperatures (below 12°C) on club development in trial 3 (Wellman 1930) and on the inhibiting effects of dry soil conditions on spore germination (Monteith 1924) in trial 5, where dry conditions prevailed after the first month of growth. The former situation would be most likely met in early spring crops or late autumn crops where soil temperature would be below 12°C

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for most of the growing period. Under these conditions chemical treatment may not always be necessary. The situation of steadily drying soil conditions (trial 5) is considered to be fortuitous and not to be relied upon, since it only takes one good irrigation or rainfall to allow new infections of unprotected roots to occur (Wellman 1930).

ACKNOWLEDGEMENTS

Thanks are due to J.F. Seelye and R.F. Eales for field work, M. Johansen for the Ohakune trial site, I. Plunkett for statistical analysis and Neil, Cropper and Co. Ltd, Henry H. York & Co. Ltd and Ivon Watkins-Dow Ltd for supplying fungicides for evaluation.

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