FUNGICIDES FOR PREVENTING CLUBROOT OF CAULIFLOWER IN LOAM AND PEAT SOILS'

D.G. Finlayson and C.J. Campbell

Abstract

Peat and sandy loam soils infested with Plasmodiophora brassicae were treated in the greenhouse with Benlate, calomel, NH_4OH, and quintozene. Blocks were seeded 0, 14, and 28 days after treatment. Fourteen days after seeding, emergence was recorded and 42 days after seeding the incidence of clubroot was assessed. NH_4OH at the highest rate seriously reduced emergence and caused severe stunting. In peat, calomel and NH_4OH reduced clubroot. In sandy loam all the treatments except the two lowest rates of Benlate reduced clubroot. NH_4OH effectively decreased acidity of the soils for about 28 days.

Introduction

Experiments from 1962 to 1965 (5) produced methods and rates of application for several insecticides to protect stem crucifers (cabbage, cauliflower, broccoli and Brussels sprouts) from damage by cyclodiene-resistant cabbage maggots, Hylemya brassicae (Bouché). During this period no attempt was made to prevent clubroot infection by Plasmodiophora brassicae Wor. In 1966 experiments were initiated to determine if the recommended. chemicals for preventing clubroot and maggot damage could be applied together and still remain compatible. The following year a large field experiment was conducted to assess fungicides, insecticides, and starter solutions applied in the transplant water (2). Several incompatibilities were noted and further work was conducted to assess pesticides applied prior to seeding of cauliflower (3). There were no apparent interactions in the combined chemicals but it was obvious that the compounds applied prior to seeding did not prevent clubroot infection. In 1969 greenhouse and field experiments were conducted to investigate the action of NH_3, NH_4OH, quintozene, and calomel (mercurous chloride) on clubroot in direct-seeded cauliflower (4). Some reduction in clubroot was noted and further experiments were conducted in the greenhouse to determine the feasibility of further field work. Cauliflower is the most sensitive of the stem brassicas to chemical treatments.

Materials and methods

Samples of clubroot-infested sandy loam and peat soils from untreated blocks of the 1969 experiments were taken in late September, held at approximately 5C for 4 months, sifted, and air-dried in the greenhouse for 24 hr before treating. Sub-samples of 4,000 g sandy loam or 3,200 9 peat, sufficient to fill seven 10-cm plastic pots, were treated with Benlate (50% benomyl [methyl 1-(butylcarbomoyl)-2-benzimidazole-carbamate], Dupont of Canada Ltd., Toronto, Ont.), calomel, or quintozene (Terraclor, 75% pentachloronitrobenzene, Olin Mathieson Chemical Corp., Little Rock, Arkansas) at various rates (Table 1). The soil samples were layered with the powdered fungicides in a plastic basin, mixed, poured into a plastic bag, thoroughly tumbled, and divided equally amongst the pots. NH_4OH (28-30% NH_3) was injected with a No. 20 hypodermic needle 4 cm below the surface of untreated soil in pots in 3 equal portions at the points of an equilateral triangle of approximately 3-cm sides in the center of the pots. Each of the 14 treatments was replicated 21 times for each soil type, i.e. 7 replicates in each of 3 blocks for sandy loam and peat. Each block was randomized so that each of the 7 rows contained every treatment. Block I was seeded 0 days after treatment; Block 111, 14 days after treatment; and Block 11, 28 days. Each pot received 6 seeds (cv. Snowball Y), 2 in the center of the pot and 1 in each of the four quadrants 3 cm from the center at diagonal right angles. The emerged seedlings were counted 14 days after seeding and thinned at that time to give a maximum of 3 seedlings per pot, one of which was in the center. Captan was applied to all blocks as a dust on the surface to prevent damping-off. Water was added topically as needed.

The seedlings were examined for clubroot 42 days after seeding. The pots were up-ended, and the soil was carefully shaken from the roots, which were then washed in clean water, and the incidence of clubroot was recorded. The index of infection was: no clubroot, 0; slight clubbing, 1; moderate, 2; severe, 3; and very severe, 4 (Fig. 1). Plants treated with Benlate and quintozene and untreated plants were placed in frozen storage for residue studies. To determine the effects of NH_4OH on the acidity of soils

Contribution No. 220, Research Station, Canada Department of Agriculture, 6660 N.W. Marine Drive, Vancouver 8, British Columbia.

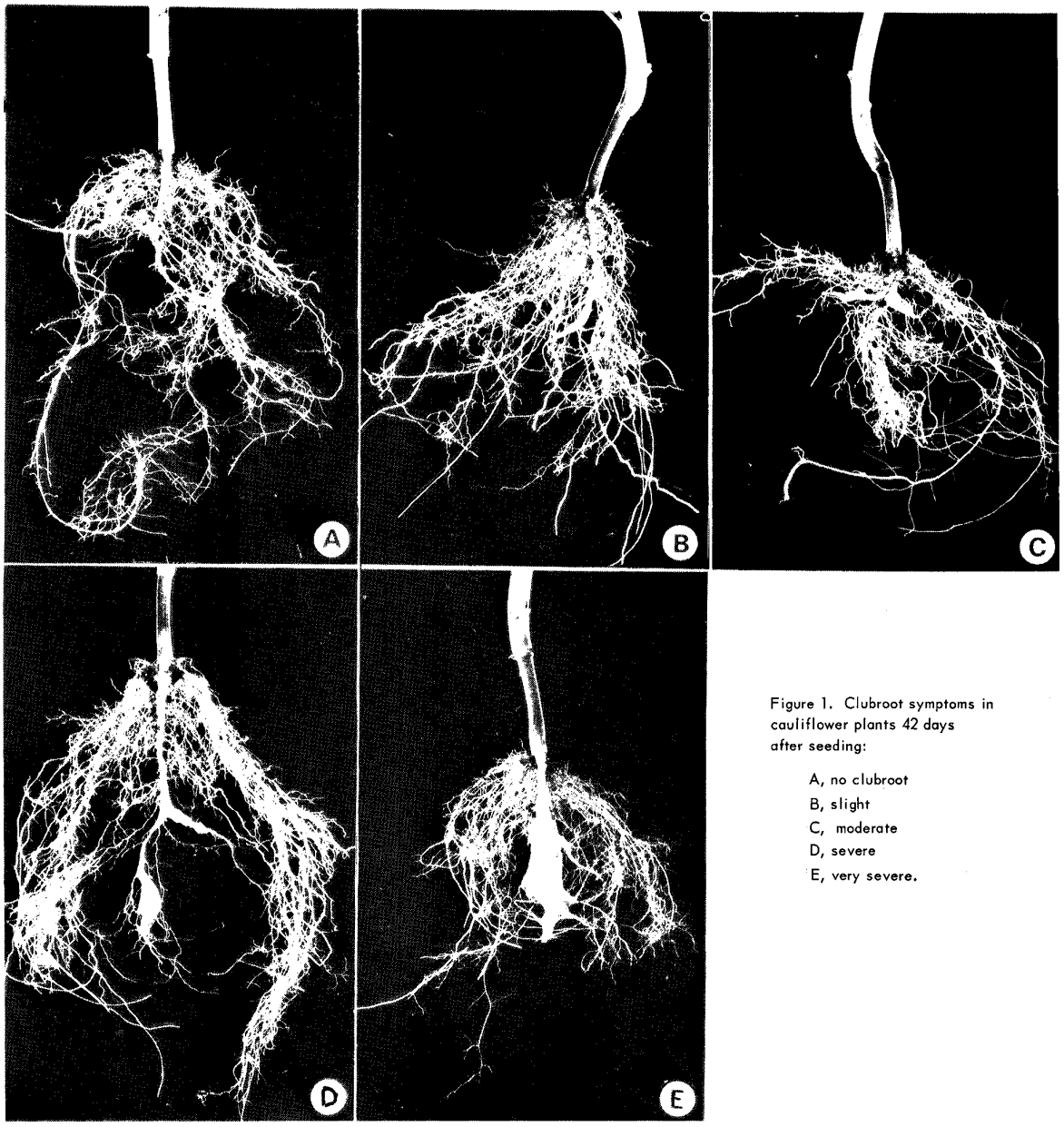

Figure 1. Clubroot symptoms in cauliflower plants 42 days after seeding:

A, no clubroot
B, slight
C, moderate
D, severe
E, very severe.

not containing plants, additional pots were treated with the 1.5 and 3.0 ml rates of NH_4OH and the pH was determined 1, 3, 5, 7, 14, and 28 days after injection.

The values for seedling emergence, and severity of clubroot (expressed as percentages of the maximum index and transformed using angle = arc sin $\sqrt{percentage}$) were examined by the analysis of variance and compared according to Duncan (1).

Results and discussion

Values for seedling emergence and clubroot infection are shown in Table 1. In both soils there was a significant reduction in the number of emergent seedlings when the pots were seeded immediately after treatment. The most severe reduction occurred in pots treated at the highest rate of NH_4OH, which also caused significant reductions in sandy loam when the values were averaged across the

Table 1. Average number of emergent seedlings per pot seeded 0, 14, and 28 days after fungicide treatment and average percentage clubroot assessed 42 days after seeding in sandy loam and peat soils

Treatment and rate (ppm active)	Number of seedlings				Percentage clubroot*			
	0	14	28	Avg	0	14	28	Avg†
Sandy *loam* ***soil***								
Benlate 20	4.3	5.3	5.6	5.1	80.0	59.5	62.5	67.3 a
Benlate 40	3.7	5.9	5.7	5.1	62.5	72.6	54.8	63.3 a
Benlate 80	2.6	5.4	5.7	4.6	41.1	2.4	0.0	14.3 bc
Benlate 160	2.1	5.4	5.4	4.3	0.0	0.0	0.0	0.0 c
Calomel 10	3.4	5.3	5.7	4.8	5.9	0.0	0.0	2.0 c
Calomel** 20	4.0	4.7	5.6	4.8	0.0	0.0	0.0	0.0 c
NH_4OH 0.75	3.1	5.0	5.4	4.5	47.2	0.0	14.3	20.5 b
NH_4OH 1.50	3.3	5.9	4.3	4.5	33.3	0.0	4.2	12.5 bc
NH_4OH 3.0	1.0	4.9	1.4	2.4††	8.3	0.0	6.3	4.9 bc
Quintozene 40	4.0	5.7	5.6	5.1	5.3	2.4	2.4	3.4 b
Quintozene 80	3.9	5.6	5.4	5.0	1.3	0.0	0.0	0.4 c
Quintozene 160	4.6	4.7	5.9	5.1	0.0	0.0	0.0	0.0 c
Quintozene 320	4.3	5.1	4.9	4.8	0.0	0.0	0.0	0.0 c
Untreated	3.9	5.6	4.9	4.7	78.8	30.9	41.7	50.5 a
Avg†	3.4 a	5.3 b	5.1 b		26.0 a	12.0 b	13.3 b	
Peat soil								
Benlate 25	2.7	5.6	5.7	4.7	64.7	65.5	20.2	50.1 a
Benlate 50	3.4	5.9	5.6	5.0	68.4	67.9	17.8	51.4 a
Benlate 100	3.6	5.4	5.4	4.6	53.8	64.3	8.3	42.1 a
Benlate 200	2.1	5.9	5.6	4.5	64.6	32.1	0.0	32.2 ab
Calomel 12.5	4.4	5.7	5.7	5.3	33.3	33.3	11.9	26.2 abc
Calomel** 25.0	4.1	5.7	5.6	5.1	0.0	15.5	3.6	6.4 bcd
NH_4OH 0.75	4.1	5.0	5.7	4.9	0.0	14.3	0.0	4.8 cd
NH_4OH 1.5	4.0	5.4	5.3	4.9	0.0	0.0	0.0	0.0 d
NH_4OH 3.0	1.9	5.2	3.9	3.7	0.0	0.0	0.0	0.0 d
Quintozene 50	3.9	5.3	5.9	5.0	72.4	14.3	14.3	33.7 ab
Quintozene 100	3.9	5.4	5.4	4.9	60.7	2.4	9.5	24.2 abc
Quintozene 200	4.7	5.0	5.7	5.1	52.4	22.6	11.9	29.0 abc
Quintozene 400	4.1	5.4	6.0	5.2	29.8	23.8	0.0	17.9 abcd
Untreated	4.3	5.7	5.6	5.2	61.9	40.5	3.6	35.3 ab
Avg†	3.7 a	5.5 b	5.5 b		40.1 a	28.3 a	7.2 b	

* Average percentage of the maximum index.

** Rates of NH_4OH are expressed in ml per 10-cm pot.

† Averages followed by the same letter are not significantly different at the 5% level (1).

†† This was the only significantly different value in the column.

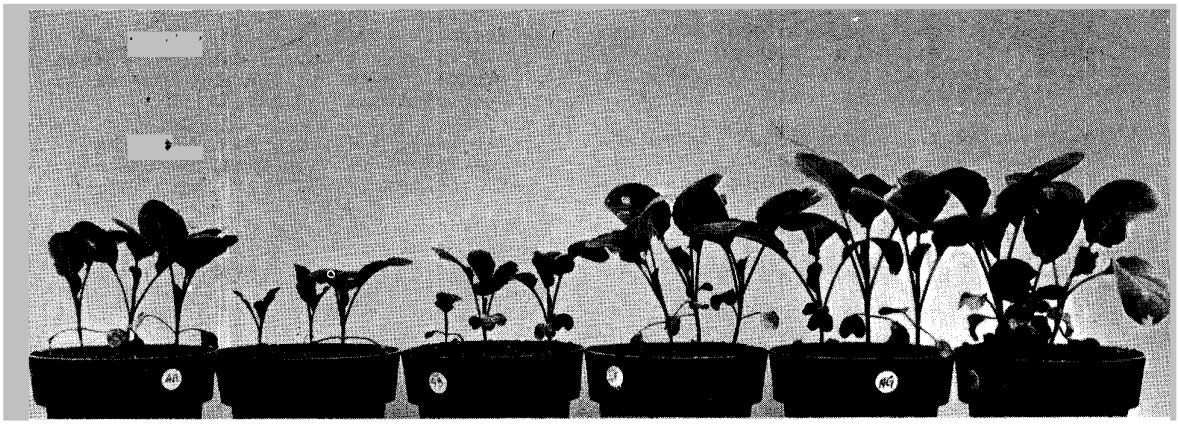

Figure 2. Effects of sail fungicide treatments on growth of cauliflower plants.

three seeding periods. In sandy loam and in peat the average number of seedlings in pots treated with 3.0 ml NH_4OH was 2.4 and 3.7 respectively, compared with the overall average of 4.6 in sandy loam and 5.0 in peat. At 1.5 ml NH_4OH, the average number of seedlings was about normal. Growth was retarded in seedlings grown in soil treated with 20 ppm calomel or 3.0 ml NH_4OH (Fig. 2).

There was significantly more clubroot in the plants when they were seeded in pots immediately after treatment than when they were seeded 28 days after treatment. However, the amount of clubroot infection in the untreated blocks also decreased during the waiting period, and this was more evident in the peat soil than in the sandy loam. In peat only the higher rate of calomel and the three rates of NH_4OH effectively reduced the incidence of clubroot. In sandy loam all treatments except the two lowest rates of Benlate reduced the amount of clubroot. This is contrary to reports by Jacobsen and Williams (6) who reported that cabbage plants grown in soil freshly nixed with benomyl (Benlate) at 0.1 to 1.6 g active material/litre of soil were free of clubroot for 35 days. Quintozene was very effective at all rates in sandy loam but was no better than the untreated controls in peat soil. Systemic clubroot, as described by Kavanagh and Williams (7), was observed in the cauliflower experiment, but it was not included in the results.

Treatment with NH_4OH decreased the acidity of the soils (Table 2). In peat the pH increased from 4.9 to 7.5 when 1.5 ml NH_4OH were used and to 8.1 when 3.0 ml were used. By 28 days the pH values were approaching those of the untreated soil. In sandy loam 1.5 and 3.0 ml of NH_4OH changed the pH from 5.5 to 8.4 and 8.9 one day after treatment; 28 days after treatment soil treated at the lower rate was back to normal, but at the 3.0 ml rate the pH was 6.7. If addition of lime to soil to decrease acidity has any bearing on lowering the incidence of clubroot, then the addition of NH_4OH merits further investigation because not only does it lower the acidity, but it also adds nitrogen to the soil through the breakdown of NH_3.

Table 2. Average pH of sandy loam and peat soils 1, 3, 5, 7, 14, and 28 days after injection with 1.5 and 3.0 ml NH_4OH per 10-un pot

Days after treatment	Sandy loam Rate NH_4OH (ml) 0	1.5	3.0	Peat Rate NH_4OH (ml) 0	1.5	3.0
1	5.5	8.4	8.9	4.9	7.5	8.1
3	5.4	8.1	8.4	4.9	7.2	7.9
5	5.4	7.9	8.2	4.9	7.1	7.9
7	5.1	7.9	8.4	4.8	6.5	7.8
14	4.8	7.0	7.9	4.7	6.0	6.6
21	5.2	6.1	7.2	4.8	5.5	6.4
28	5.2	5.4	6.7	4.9	5.1	6.0

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