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INSECTICIDES, FUNGICIDES AND LIME COMBINED FOR CONTROL OF CABBAGE MAGGOTS, CLUBROOT AND WIRE STEM[1]

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ABSTRACT

Insecticides alone or in combinations with lime, mercurous chloride and quintozene were applied to peat and loam soils for control of clubroot, **Plasmodiophora brassicae** Wor., and cabbage maggot, **Hylemya brassicae** (Bouché), in cauliflower. The effects were assessed by counting the emergent seedlings, by weighing the mature cauliflowers, and by uprooting plants at harvest and grading the maggot damage and incidence of clubroot. Split applications, one at seeding and one 30 days later with Birlane, Dasanit or carbofuran protected cauliflower from maggot damage until harvest. Carbofuran allowed the least maggot damage in both soils. Zinophos was comparatively effective in peat soil but not in sandy loam. The insecticides had no significant effect on germination or clubroot. Quintozene gave satisfactory protection from clubroot and wire stem in sandy loam and had the lowest incidence of clubroot in peat soil. The fungicides had no effect on maggot damage, nor did they appear to influence the insecticides. No significant interactions were observed. The effect of the insecticides and fungicides on yield was somewhat masked by over-seeding.

Introduction

Previous experiments (Finlayson and Noble, 1966; Finlayson *et al.*, 1967; Freeman and Finlayson, 1968; and Finlayson, 1969) have shown that direct-seeded and transplanted cruciferous crops can be protected from maggot damage. However, fungicides and insecticides applied together have damaged crops (Finlayson, 1969 and Ranney, 1964) and when herbicides and insecticides were applied to the same area significant reductions in yields of cabbage were recorded (Freeman and Finlayson, 1968). With the increasing cost of labor, a method for direct-seeding of stem crucifers is needed but this practice requires methods for controlling cabbage maggot (*Hylemya brassicae* (*Bouché*)) and wire stem (*Rhizoctonia solani* Kuhn.) in the young seedlings and clubroot (*Plasmodiophora brassicae* Wor.) throughout the growing season. Furthermore, methods and rates for

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applying herbicides must be developed to eliminate the need for handweeding.

Experiments were designed to determine if fungicides could be applied to reduce the amount of wire stem and clubroot infection but not interfere with the action of insecticides on the cabbage maggot. This paper reports investigations with insecticides and fungicides with and without lime, on sandy loam and peat soil in British Columbia.

Materials and Methods

The insecticides, Birlane, Dasanit, diazinon, Furadan (carbofuran) and Zinophos were selected because of their effectivness and current or pending registration for use against cabbage maggot. Lime was used because there was a long-standing recommendation to produce a basic soil condition and thus reduce clubroot infection. The fungicides, mercurous chloride (calomel) and quintozene were selected because they are recommended, among other places, in Great Britain (United Kingdom Ministry of Agriculture, 1965), British Columbia (British Columbia Department of Agriculture, 1968), and Ontario (Ontario Department of Agriculture and Food, 1968) respectively. Quintozene has the added characteristic of reducing wire stem. Cauliflower, var. Snowball, was used because it is very susceptible to attack by maggots and to infection with clubroot and wire stem. Common names for pesticides are used in the text, but where these have not been assigned, registered names are used.

The experiment was replicated four times in sandy loam at Abbotsford and another four times in peat soil at Victoria. Each replicate was divided into six blocks representing the fungicide-lime treatments, and each of these blocks was further divided into six sub-plots representing the insecticide treatments. The blocks were treated as follows: untreated; lime; calomel; calomel with lime; quintozene; and quintozene with lime. The lime, at 1500 lb/acre (1680 kg/hectare), was broadcast and disked into the soil approximately four weeks before seeding. At Abbotsford the lime was applied to the 12 blocks and randomized with three in each replicate. At Victoria high winds were such that the lime was applied to one half of the site, or 12 blocks. Calomel at 4 lb (4.5 kg/hectare) and quintozene at 60 lb (67.2 kg/hectare) per acre were broadcast and disked into the soil several days before seeding. Each of the insecticide sub-plots was a 25-foot row (7.6 m). The insecticides were applied as granules with a shaker at 2 oz (56.7 g) toxicant per 1000 ft (305 m) in a 4 inch band (10 cm) over the seeded row, and raked gently into the top inch (2.5 cm) of soil. The insecticides were reapplied as drenches of 2 oz (56.7 g) toxicant per 1000 ft (305 m) of row in 7 gal (31.8 liters), 30 days later to wet the plants and 3 inches (7.6 cm) on each side of the row.

The effects of the treatments were assessed by counting the emergent seedlings 20 days after seeding, by weighing the mature cauliflowers, and by uprooting 10 plants at harvest in each sub-plot and grading the incidence of both maggot damage and clubroot. The roots were graded as follows: no damage or clubroot, 0: light, 1; moderate, 2; severe, 3; very severe, 4.

The grades of maggot damage or clubroot for each plant were added to determine the sub-plot totals. These figures were then expressed as percentages of the maximum that could occur.

The data were coded and key-

punched, the analyses of variance calculated on a computer, and the results compared by Duncan's multiple range test (Duncan, 1955).

Results and Discussions

Germination

The average number of emergent seedlings in 25 feet of row for the insecticides ranged from 110 to 116 in peat and 107 to 116 in loam. There were no significant differences. However, when the number of seedlings was averaged within blocks for the fungicide-lime treatments the differences were significant at both locations. In peat they ranged from 103 seedlings with calomel to 121 with lime. The treatments with lime plus quintozene and lime alone had significantly more seedlings than the 110 in the untreated block. In loam the range was 106 seedlings with calomel plus lime to 125 where only quintozene was applied. The untreated block averaged 112 seedlings. The calomel plus lime block had significantly less seedlings than the quintozene-treated block, which had significantly more seedlings than the block receiving no treatments for diseases.

Clubroot

In the sandy clay loam the percentage incidence of clubroot ranged from 8.8 to 10.0 for the insecticide treatments, and 25.8 in the plots where no lime, fungicides or insecticides were applied. When averaged across the blocks where insecticides were applied, but no lime or fungicides, the amount of clubroot was 20.5% (Table 1). The insecticides had no effect on the incidence of clubroot infection. Although the incidence of clubroot was considerably higher in the peat soil the insecticides did not affect the action of the fungicides nor did they lessen the amount of clubroot. Table 1 shows the effects of lime and fungicides on clubroot. Quintozene was the most effective fungicide.

TABLE 1—Average percentage of clubroot in cauliflower after various treatments in two types of soil, 1968.

Treatment	Percentage of clubroot*	
	Peat Soil	Sandy Clay Loam
Untreated	74.5 ab	20.5 c
Lime	72.3 ab	7.3 ab
Calomel	74.5 ab	7.8 ab
Calomel and Lime	76.8 ab	13.8 bc
Quintozene	63.5 a	2.5 a
Quintozene and Lime	89.0 c	4.8 a

* Values followed by same letter are not significantly different at 5% level (Duncan, 1955).

Maggot Damage

In both soils carbofuran had the least maggot damage regardless of the addition of lime or fungicides (Table 2), but in the clay loam it was not significantly better than Birlane or Dasanit. In the peat soil carbofuran was closely followed by Zinophos, Dasanit and Birlane. Diazinon was only slightly better than no treatment at all. It is interesting to note that Zinophos gave consistently better protection from maggot damage in the peat soil than in the sandy loam, regardless of the addition of the other chemicals.

Yield

In the sandy loam the effects of maggot and clubroot control are reflected by increased yields (Table 3). Blocks treated to reduce clubroot produced significantly higher yields than those untreated. For the insecticides the pattern was less definite. However, the two most effective insecticides gave yields which were significantly better than those with no insecticides.

TABLE 2—Average percentage maggot damage after various treatments to control clubroot infection and maggot damage to cauliflower in two types of soil, 1968*.

Treatment: Fungicides \ Insecticides	Birlane	Carbofuran	Dasanit	Diazinon	Zinophos	Untreated	Average
Peat Soil							
Untreated	21.3	3.8	11.3	58.3	10.0	53.3	26.3 a
Lime	10.8	7.0	10.8	37.0	7.5	43.8	19.5 a
Calomel	15.0	5.0	13.3	48.8	15.0	65.0	27.0 a
Calomel and Lime	12.0	8.8	12.5	30.8	12.5	43.3	20.0 a
Quintozene	8.3	6.3	15.0	49.5	9.5	61.3	25.0 a
Quintozene and Lime	10.8	6.3	8.3	37.0	11.3	52.0	20.8 a
Average	13.0 c	6.3 d	11.8 cd	43.5 b	11.0 cd	53.0 a	
Sandy Clay Loam							
Untreated	5.8	15.8	7.0	42.0	35.8	53.8	26.5 a
Lime	3.8	5.0	15.0	50.0	34.5	43.8	25.3 a
Calomel	6.3	3.3	8.3	38.8	20.0	42.5	19.8 a
Calomel and Lime	15.0	9.5	10.0	47.0	34.5	55.8	28.5 a
Quintozene	10.0	2.5	3.8	35.8	29.5	56.3	23.0 a
Quintozene and Lime	5.0	5.0	15.8	52.5	43.8	55.8	29.5 a
Average	7.5 c	6.8 c	10.0 c	44.3 a	33.0 b	51.3 a	

* Values followed by the same letter are not significantly different at the 5% level (Duncan, 1955).

In the peat soil the results were not so clear. Quintozene had the highest yield but not significantly greater than no treatment. The effect of treating one half of the site with lime because of the wind and leaving

TABLE 3—Average yield of cauliflower, kg 7.6m (25 feet), after various treatments for clubroot and maggot damage in two types of soil, 1968*.

Treatment: Fungicides \ Insecticides	Birlane	Carbofuran	Dasanit	Diazinon	Zinophos	Untreated	Average
Peat Soil							
Untreated	9.8	9.9	8.5	8.8	7.8	9.2	9.0 ab
Lime	7.4	7.9	5.0	5.9	7.1	7.7	6.8 bc
Calomel	10.4	9.7	7.6	13.1	9.3	7.9	9.7 a
Calomel and Lime	6.2	6.3	5.7	7.5	5.6	6.0	6.3 c
Quintozene	9.5	10.4	10.7	11.4	10.6	10.3	10.5 a
Quintozene and Lime	7.0	7.5	7.0	6.4	6.5	7.3	6.9 bc
Average	8.4 a	8.6 a	7.4 a	8.9 a	7.8 a	8.1 a	
Sandy Clay Loam							
Untreated	6.5	6.7	5.1	5.6	6.8	5.2	6.0 b
Lime	7.4	8.9	8.5	6.9	7.9	5.6	7.5 a
Calomel	8.8	8.4	7.5	8.9	7.5	6.0	7.9 a
Calomel and Lime	8.2	10.1	7.6	9.3	9.4	5.5	8.3 a
Quintozene	10.3	9.1	7.6	8.6	8.0	8.3	8.6 a
Quintozene and Lime	8.8	9.4	8.0	8.7	7.3	9.6	8.6 a
Average	8.3 a	8.8 a	7.4 ab	8.0 ab	7.8 ab	6.7 b	

* Values followed by the same letter are not significantly different at the 5% level (Duncan, 1955).

the other half untreated showed up in the clubroot appraisal and is reflected in the yield. Although clubroot was serious on both halves of the site, the side treated with lime averaged 10% more clubroot than the side without lime. This difference was one of two contributing factors which resulted in the untreated sub-plot yield averaging 9.2 kg. It is even more apparent when the average yield for the limed and unlimed sides are compared. The average yield for the unlimed side, where the soil appeared less infective, was 9.7 kg, whereas the limed side averaged only 6.7. Differences between yields for the insecticides were not significant.

The second factor was over-seeding. The insecticides had little effect on yield because over-seeding in both soils produced on the average 113 emergent seedlings in peat soil and 114 in the sandy loam. When these were thinned to approximately 30 plants per sub-plot, the healthy, best looking plants were left and the weaker ones were pulled; thus at 4 weeks untreated plots still had approximately the same number of plants as treated plots. A count of seedlings pulled at thinning in sandy loam, revealed the relationship of maggoty-plants and plants with wire stem as follows:

Maggoty-Plants

Birlane	3	Diazinon	7
Carbofuran	4	Zinophos	9
Dasanit	13	Untreated	128

Wire Stem

Untreated	74	Calomel and lime	32
Calomel	57	Quintozene and lime	18
Quintozene Lime	24 52		

By leaving healthy plants it appears that when the second generation of maggots attacked the cauliflower, the plants were big enough to produce a head in spite of the maggots.

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