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The control of club-root (Plasmodiophora brassicae Wor.) on cabbage seedlings with trifluralin and napropamid herbicides

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Abstract

The herbicides Treflan EC 2 (24% trifluralin) and Devrinol 50 (50% napropamid) applied separately decreased efficiently the incidence of club-root on cabbage seedlings in pot experiments. If these herbicides were applied together with the fungicide Bavistin (50% carbendazim) the control of the disease was in some cases more efficient, as compared with Bavistin used alone. The higher the organic matter content in the soil, the lower the phytotoxicity and club-root controlling activity of herbicides. Thus, on peat soil the herbicides could be applied in much higher rates than on pseudopodsolic soil.

INTRODUCTION

Several investigators imply that herbicides may influence fungus diseases in crop plants. Herbicides may increase susceptibility of different plants to fungus diseases (Altman 1969; Grummer 1960; Katan and Eshel 1972; Wyse et al. 1976). There is also evidence that some herbicides may help in controlling particular diseases. For example, terbutrin decreased the incidence of *Erysiphe graminis* on wheat (Heitefuss and Brandew 1970).

We know of only one paper reporting the inhibitory effect of herbicides on *Plasmodiophora brassicae* infection. Buczacki (1975) observed in a greenhouse experiment that trifluralin decreased markedly the incidence of this pathogen on cabbage seedlings.

Trials were recently made to control club-root with the fungicide Bavistin and other systemic fungicides. In four year experiments, the effectiveness of Bavistin against this disease was also checked in Poland (Robak and Rondomański 1972; Robak 1974). It was shown that for efficient control of club-root, Bavistin must be used in a very

high amount ranging from 80-100 kg/ha, which makes this treatment costly and soil polluting.

One aim of the present experiment was to develop a method of using herbicides to control weeds as well as *P. brassicae*. Another was to check the effect of simultaneous applications of herbicides and the club-root controlling fungicide, Bavistin.

METHODS

The experiments were carried out with seedlings of cabbage cv. Ditmarska grown in pots in a greenhouse having wire net in place of side walls.

Experiment I: two kinds of soil with different organic matter content were used: 1 — pseudopodsolic soil from Skierniewice, with 1,5% organic matter, and pH_{H_2O} — 7.0; 2 — peat soil from Rekowow near Gdynia, which contained 75% organic matter, its pH_{H_2O} was 4.8. Inoculation was performed with spores of *P. brassicae* at a concentration of 10^7 in 1 cm^3 of soil. Spores were counted using an hemacytometer. The following pesticides were applied at rates given in Tables.

1. Treflan EC 2 containing 240 g of trifluralin per liter.
2. Devrinol 50 WP containing 50% napropamid.
3. In some combinations herbicides were applied together with the fungicide Bavistin containing 50% carbendazim.

Plastic-pots, 20×20×7 cm, were filled with infested soil mixed with herbicides and then 16 seeds of cabbage were sown in each pot. The experiment was performed between late May and early July.

Experiment II was based on the some principle as experiment I., the only difference being that 4 mixtures of soil were used:

	organic matter content in %	pH H_2O
1. Pseudopodsolic soil	1.5	6.7
2. Pseudopodsolic soil + peat soil 3:1 (by volume)	7.5	6.1
3. Pseudopodsolic soil + peat soil 1 : 1 (by volume)	17.0	6.2
4. Peat soil	75.0	5.0

In this experiment herbicides were applied in 3 concentrations, (Table 2). This experiment was conducted from early August through mid September.

Experiment III, in which Bavistin was used jointly with herbicides, was carried out at the some time as experiment II. The treatments are shown in Table 4. The design of all experiments was planned in such a way that "two-factor analysis" was possible. The type of soil was

the main factor, whereas the herbicides and their rates were the secondary ones.

Experiment I was set up with four replications, and the other two with three replications. All experiments were completed 42 days from the time of seed germination. The above-ground parts of cabbage seedlings were weighed, and the infection of the root system by *P. brassicae* was estimated according to a 6 step scale: 0-healthy root system and 5-roots completly affected by club-root (uniform necrosis on the roots, lack of branching roots, dying plant).

RESULTS

To understand better the action of the herbicides in these experiments, it has to be taken into account that the incidence of *P. brassicae* infection depends greatly on the content of organic matter in the soil. The higher its content, the heavier the infection by *P. brassicae* (see controls in Tables 1 and 3). This correlation was also observed in earlier experiments (Robak and Rondomański 1972; Robak 1974).

Both herbicides used, Treflan EC 2 and Devrinol WP 50, were very effective in controlling club-root on cabbage seedlings (Tables 1, 2 and 3). However, their effectiveness, as well as phytotoxicity, depended markedly on the type of the soil. On pseudopodsolic soil, Treflan EC 2 at a rate of 12 ml/m^3 did not inhibit cabbage growth but markedly diminished the incidence of club-root. This rate equals about 8 l/ha if mixed with the upper 7 cm layer of the soil. Recommended concentrations for weed killing are 2.5–3 kg/ha.

On peat soil or on the podsolic soil enriched with organic matter (by mixing with peat soil) both herbicides were much less effective against club-root that on pseudopodsolic soil, but, on the other hand, much higher rate could be used due to smaller phytotoxic effects. Thus with both, Treflan EC 2 and Devrinol 50 WP, in concentrations 48 ml/m^3 and 48 g/m^3, respectively, the seedlings in most cases showed consistently better growth than the controls, and, additionally, the incidence of *P. brassicae* infection was markedly decreased. Concerning Treflan EC 2, the plants on peat were able to resist even a concentration of 220 ml/m^3, i. e., 18 times higher than on the pseudopodsolic soil. A gradual decrease in chemical phytotoxicity by augmentation of organic matter content in the soil was found earlier by several workers (Adams 1973; Horowitz et. al. 1974; Dobrzański 1976).

The fungicide Bavistin in concentrations of 100 and 200 g/m^3 showed no visible phytotoxic effects and was very effective in controlling club-root on both types od soil (Table 4). However, it must be stressed that the herbicides used in experiments I and II showed similar effects

Table 1

Effects of herbicides Treflan EC 2 and Devrinol 50 WP on cabbage growth and on the incidence of club-root on two different soils
(Experiment I)

Treatment	Rates of chemicals * in ml/m³ or in g/m³	Weight of plants in g		Average club-root incidence on roots rated from 0-5 (see Methods)	
		pseudo-podsolic soil	peat soil	pseudo-podsolic soil	peat soil
Treflan EC 2	3	36.1e	73.6ghi	1.3	—
Treflan EC 2	12	28.1de	64.0fg	0.5	—
Treflan EC 2	48	13.6b	70.6fgh	0.0	4.4
Treflan EC 2	220	0.0a	90.3j	—	3.0
Devrinol 50 WP	3	29.4de	74.5hi	0.3	4.3
Devrinol 50 WP	12	16.4bc	71.8fgh	0.0	4.9
Devrinol 50 WP	48	0.0a	91.4d	—	2.7
Devrinol 50 WP	220	0.0a	17.0bcd	—	0.0
Treflan + Bavistin (fungicide)	3+100	30.7de	82.5ij	0.0	1.5
Treflan + Bavistin (fungicide)	48+100	15.0bc	105.4k	0.0	1.3
Bavistin (fungicide)	100	25.2bcd	113.7k	0.0	1.9
Control	—	20.7bcd	61.5f	2.0	5.0

LSD for α=0.05 for soils = 2.99
for herbicides = 7.31
soils × herbicides = 10.34

* Treoflan w ml/m³
Devrinol w g/m³

when given at optimal rates. Jointly using Bavistin and each of two herbicides investigated produced only a slightly better control of *Plasmodiophora brassicae* than using Bavistin alone. Sometimes, application of such mixtures resulted in decreased weight of seedlings which may be interpreted as increasing of phytotoxic effects. Possibly, better results could be obtained if the rates of the components were lowered by half in the mixture, as compared with their concentrations when used alone.

DISCUSSION

The main aim of herbicide application is weed control. Their additional inhibitory influence on serious plant diseases may be, however, of great practical importance.

At present *Brassicae* vegetables are planted in Poland almost exclu-

Table 2

Effects of herbicides on cabbage development in different soils (Experiment II)

Herbicide	Rates of herbicides * in g/m³ or ml/m³	Weight of plants in g in different soils			
		pseudo-podsolic soil	pseudo-podsolic soil +peat 3:1	pseudo-podsolic soil +peat 1:1	peat
Treflan EC 2	12	31.8bcd	36.5cde	59.6ij	46.9efgh
Treflan EC 2	48	7.4a	36.6cde	54.6ghij	62.3j
Treflan EC 2	220	0.0a	2.5a	21.0b	59.6ij
Devrinol 50 WP	12	26.6bc	31.7bcd	57.4hij	65.4j
Devrinol 50 WP	48	3.8a	37.4cde	42.6def	77.3k
Devrinol 50 WP	220	0.0a	0.0a	0.0a	38.2cdef
Control	—	32.0bcd	37.1cde	50.0fghi	43.6defg

LSD for α=0.05 for soils = 4.51
for herbicides = 5.97
soils × herbicides = 11,94

* Patrz tab. 1 — See Table 1.

Table 3

Effects of herbicides and of soil type on club-root indicidence on cabbage (Experiment II)

Treatment	Rates of herbicides in g/m³ or ml/m³	Incidence of club-root rated in 0-5 scale (see Methods) in different types of soil:			
		pseudo-podsolic soil	pseudo-podsolic soil +peat 3:1	pseudo-podsolic soil +peat 1:1	peat
Treflan EC 2	12	0.4	2.0	3.1	3.9
Treflan EC 2	48	0.0	1.1	2.2	3.6
Treflan EC 2	220	—	0.1	0.0	1.9
Devrinol 50 WP	12	0.0	1.5	2.0	3.8
Devrinol 50 WP	48	0.0	0.9	0.9	1.9
Devrinol 50 WP	220	—	—	—	0.4
Control		1.7	1.9	2.8	4.1

sively from transplants. The trend is, however, to sow the plants directly into permanent place. This change also influences the practice of fungicide application. The fungicides controlling club-root could be easily used to treat transplants as a dip-method but their application in the field where cabbage is sown, is much more difficult and costly. For instance the recommended rate of Bavistin in this case is 80-100 kg per ha. On the other hand, such great amounts of fungicide add unnecessary chemicals to the environment.

As was shown in the present experiments, the herbicides Treflan

Table 4

Combined effect of herbicides and of the fungicide Bavistin on cabbage growth and on club-root incidence in two different types of soil (Experiment III)

Treatment	Rates of chemicals * in g/m³ or ml/m³	Plant weight in g		Average club-root incidence on roots (scale 0-5)	
		pseudo-podsolic soil	peat	pseudo-podsolic soil	peat
Treatment					
+Bavistin	48+200	9.5a	75.5de	0.0	2.5
Devrinol 50 WP					
+Bavistin	48+200	2.3a	69.0d	0.0	2.1
Bavistin	200	28.8b	81.3e	0.4	2.8
Control		34.1bc	43.6c	1.9	4.3

LSD for α=0.05 for soils = 4.40
for herbicides = 5.77
soils × herbicides = 10.92

* Patrz tab. 1 — See Table 1.

EC 2 and Devrinol 50 WP controlled club-root to a similar extent as Bavistin (Table 1). This means that controlling weeds with these herbicides gives two additional adventages — eliminating the high costs of using fungicide, and avoiding excessive pollution of the soil with fungicides.

Club-root control by Treflan EC 2 and Devrinol 50 WP may result from either the direct effect of herbicides on the pathogen or from the change evoked by them in soil microflora, which may produce unfavorable conditions for *Plasmodiphora* development.

The use of series of different soil mixtures (in experiment II) revealed a distinct correlation between the content of organic matter in the soil and the incidence of club-root and with decreasing herbicide effectiveness and phytotoxicity.

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Wpływ herbicydów trifluraliny i napropamidu na porażenie kapusty z siewu przez kiłę kapusty (*Plasmodiophora brassicae* Wor.)

Streszczenie

W doświadczeniach wazonowych herbicydy Treflan EC 2 (26% trifluralina) w ilości 12 ml/m³ i Devrinol 50 WP (50% napropamid) — w ilości 12 g/m³ gleby zapobiegały prawie całkowicie porażeniu korzeni kapusty przez grzyb powodujący kiłę kapusty na glebie pseudobielicowej.

W glebach o większej zawartości materii organicznej, przez dodatek do gleby pseudobielicowej torfu niskiego, grzybobójcze działanie herbicydów malało, a jednocześnie spadała ich fitotoksyczność, dzięki czemu można było podnieść dawki herbicydów.

W samej glebie torfowej wyraźne zmniejszenie porażenia przez grzyb uzyskano przez dodatek Treflanu EC 2 powyżej 48 ml/m³ i Devrinolu 50 WP powyżej 48 g/m³. Łączne stosowanie fungicydu Bavistin (zawierającego 50% karbendazimu) z herbicydami, niekiedy w większym stopniu ograniczało porażenie siewek kapusty przez kiłę niż sam fungicyd.