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BIOLOGICAL, CHEMICAL AND INTEGRATED CONTROL OF RHIZOCTONIA SOLANI IN POTATO

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ABSTRACT

Jager, G., Velvis, H., Lamers, J.G., Mulder, A. and Roosjen, Js., 1990. Biological, chemical and integrated control of *Rhizoctonia solani* in potato.

The effects of biological, chemical and integrated control on the formation of sclerotia of *Rhizoctonia solani* on new potato tubers were studied in experimental fields on neutral marine loams and slightly acid sands. Sprouts of seeds sprouted in daylight were inoculated with conidia of *Verticillium biguttatum*, an obligate mycoparasite of *R. solani*. Fungicides at the desired dosage rates were sprayed on the soil and mixed with it.

Biological control increased the percentage of harvests with less than 5% loss due to grading from 24% (non-inoculated) to 56%. Chemical control at the recommended dosage rate usually gave good results. Lower doses were less effective in sand than in loam soils, but combined with biological control the results were often good: harvests with less than 5% loss due to grading increased from 56 to 81%. Integrated control with 1/4 Monceren was about equal to chemical control with 1/1 Monceren. The results were obtained under conditions favouring formation of sclerotia on tubers. Better results are expected with improved methods of harvesting. Advantages of integrated control are discussed.

INTRODUCTION

Rhizoctonia solani is an important source of damage in potato growing. The production of sclerotia (black scurf) on harvested seed potatoes can lead to severe and frequent losses of marketable tubers. The formation of chats, which are not lifted, is increased by *R. solani* (Mulder and Roosjen, 1981) and after mild winters leads to "potato-weed", a source of lasting troubles with potato pests and diseases.

Of the two sources of infection, i.e. the seed tuber and the soil, the infection on the seed tuber can be easily eliminated. The infection from the soil was not a problem when potatoes were grown at intervals of five years or more. As cultivation of potatoes became more profitable, the frequency of potato growing increased and also the damage from *R. solani* (Scholte, 1987, 1989; Lamers, 1989). Besides, the formation of sclerotia on young tubers was aggravated by chemical haulm destruction (Mulder et al., 1979; Dijst, 1985), a common farm practice that should be replaced by a method of harvesting that does not stimulate formation of sclerotia (Dijst, 1985; Turkensteen et al., 1989).

Sclerotia from potato tubers grown in a variety of soils were often found to be colonized by other fungi of which the predominating one was a *Verticillium* species (Jager and Velvis, 1983). This fungus was able to kill sclerotia (Velvis and Jager, 1983) and hyphae of *R. solani* (Jager et al., 1979) and to protect young sprouts from penetration by *R. solani* (Velvis and Jager, 1983). This fungus, *Verticillium biguttatum* (Gams and Van Zaayen, 1982), an obligate parasite of *R. solani* (Van den Boogert, 1989) proved to be very useful for biological control of *R. solani* in potato (Jager and Velvis, 1985, 1986).

Specific anti-Rhizoctonia fungicides (Rizolex and Monceren with tolclofos-methyl and pencycuron as the active ingredients, respectively) have been available since 1982 and 1984 and so the importance of the soil as a source of infection can be minimized.

Results of field experiments are reported in which biological, chemical and integrated control measures were carried out. The complete data set has been presented in an extensive report (Jager et al., 1989).

2 MATERIALS

2.1 Media.

The media used for growth of *R. solani* and *V. biguttatum* were described by Van den Boogert and Jager (1984).

2.2 Detection of *R. solani* and *V. biguttatum* on subterranean parts of the potato plant.

The procedure was as described by Velvis and Jager (1983) and Van den Boogert and Jager (1984).

2.3 Potato variety.

The variety Bintje was used in most cases. In some experiments on sandy soils Prominent was used and, only once, the variety Astarte.

2.4 Disinfection of seeds.

Disinfected seeds were included in each field to get an idea of the degree of infection from the soil. On a few fields on sandy soils all seeds were disinfected.

2.5 Sprouts.

All seed tubers were sprouted in daylight. Sprouts are a prerequisite for biological control. They are the carriers of conidiospores of *V. biguttatum*. The size of the sprouts determines the amount of spores that can be transported to roots, stems and stolons (Van den Boogert, 1989). Sprouts with a length of 1.5 - 2 cm proved to be sufficiently large.

2.6 Inoculation.

Potato sprouts were inoculated with a suspension of spores and hyphal fragments of *V. biguttatum* (isolate M73) in 0.5% CMC (carboxy-methyl-cellulose, Na-salt, high viscosity; BDH) in tapwater. 0.1% KH_2PO_4 was added to keep the suspension slightly acid. The number of spores was determined with a haemacytometer and adjusted to 1-3 x 10^6 ml^{-1} by dilution. Hyphal fragments were ignored. Sprouted tubers were dipped in the suspension or sprayed with it to cover the sprouts with the spore suspension. Spraying was done with the equipment on the planting machine normally used for spraying Monceren.

2.7 Fungicides.

These were sprayed on the soil surface as a suspension in water (300 $l.ha^{-1}$) at the dosage required. The fungicide was mixed with the 10 cm top layer, from which the ridges were made, shortly after application. The amounts applied were the recommended rate (1/1) and lower (1/2, 1/4, 1/8 up to 1/10). The recommended rate was 20 $kg.ha^{-1}$. The rate was increased as the soil's organic matter content was higher. (50% more fungicide was applied in soils with an organic matter content of 10%.) The following fungicides were used: Monceren, Rizolex and Basitac (a new fungicide at the time, but not registered in the Netherlands in view of environmental drawbacks and disappointing results.)

2.8 Field experiments.

The effect of biological, chemical and integrated control on the formation of sclerotia on young tubers, expressed as the percentage of rejects after grading (Jager et al., 1989), was studied in field experiments. Each field was designed as a split-plot experiment, in which each treatment was replicated 4 to 10 times. Young tubers were harvested periodically or three weeks after haulm destruction. Haulm destruction took place at the end of July or in early August. Harvested tubers were treated as described by Jager and Velvis (1985). They were classified according to James and McKenzie (1972).

The percentage of loss due to grading (sv) was calculated from the weights of each class according to the requirements of the NAK (General Dutch Inspection Service for Agricultural Seeds and Seed Potatoes) for grade A seed potatoes. (All tubers heavily and moderately speckled with sclerotia must be discarded, plus the amount of lightly speckled tubers in excess of 1/3 of the total amount of clean plus very lightly speckled tubers). The sv is preferred as it is more practical and more precisely defined than the sclerotium index.

2.9 Soils.

The fields were situated on neutral marine loam soils (pH 6.7-7.6; soil organic matter (s.o.m.) 1.4-2.1%), on slightly acid pleistocene sandy soils (pH 5.1-5.4; s.o.m. 4.2-6.2%) and on reclaimed sphagnum peat soils (pH 4.5-5.2; s.o.m. 9.2-13.5%).

2.10 Statistical evaluation.

When the distribution of sv was symmetrical, an ordinary analysis of variance followed by pairwise comparisons was used to test differences between treatments. When the frequency distribution was skew, as was the case with low values of sv, a Kolmogorov-Smirnov test was used.

3 RESULTS

3.1 Biological control

The effect of biological control is presented in Figure 1. Average sv values for the harvests from non-inoculated and inoculated seed from the same field have been plotted, and the line of no effect (x = y) is given. It is clear that all points but three lie above the line: biological control clearly tends to reduce sv values. The reduction, however, was not always statistically significant (P = 0.05).

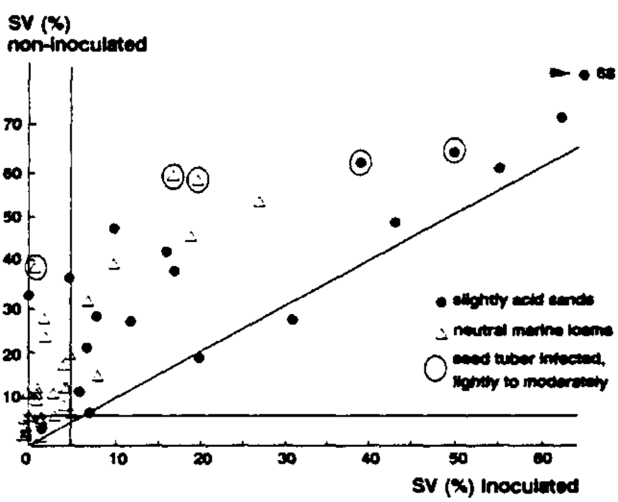

Figure 1. Biological control (inoculated) versus no control with sv as criterion. Each point represents the average loss from the plots in an experimental field.

If a loss of 5% due to grading is accepted as the upper limit, the harvest from 24% of the non-inoculated fields meets this requirement (points between the horizontal axis and the horizontal line at 5%). Biological control, however, results in 56% of harvests meeting this demand (points between the vertical lines at 0 and 5% loss). The majority of the fields represented by points that meet the requirement lie on neutral marine loams. In slightly acid sandy soils biological control was often less effective.

3.2 Integrated control

a. Laboratory experiments. Rizolex and Monceren are recommended and used mainly against *R. solani* in the soil. The effect of these fungicides and Basitac, at different concentrations, on the growth rate of *R. solani* and *V. biguttatum* on malt-peptone-agar showed that *V. biguttatum* was the more sensitive of the two organisms to Rizolex and Monceren (range 0-50 $mg.kg^{-1}$) and *R. solani* to Basitac.

In slightly acid sandy soil the combination of inoculation of sprouts with *V. biguttatum* and a soil treatment with 0.5 and 0.1 of the recommended dose of Rizolex and Monceren afforded very good protection of potato sprouts against *R. solani* (Fig. 2). Monceren and also Rizolex appeared to be very suitable for integrated control. Both rates of Monceren and the lowest rate of Rizolex increased, indirectly, via *R. solani*, the amounts of *V. biguttatum* originating from the soil on potato sprouts. *V. biguttatum* inoculated on sprouts was not adversely affected (Jager, 1987).

b. Field experiments. Laboratory experiments were followed by field experiments aiming at integration of biological and chemical control. Results of biological, chemical and integrated control were compared.

b1. Biological control. The effects of biological control were not different from those obtained earlier; they are included in Figure 1.

b2. Chemical control. On most fields chemical control usually reduced sv significantly. Low rates were relatively more effective in neutral marine loam soils than in slightly acid sandy soils.

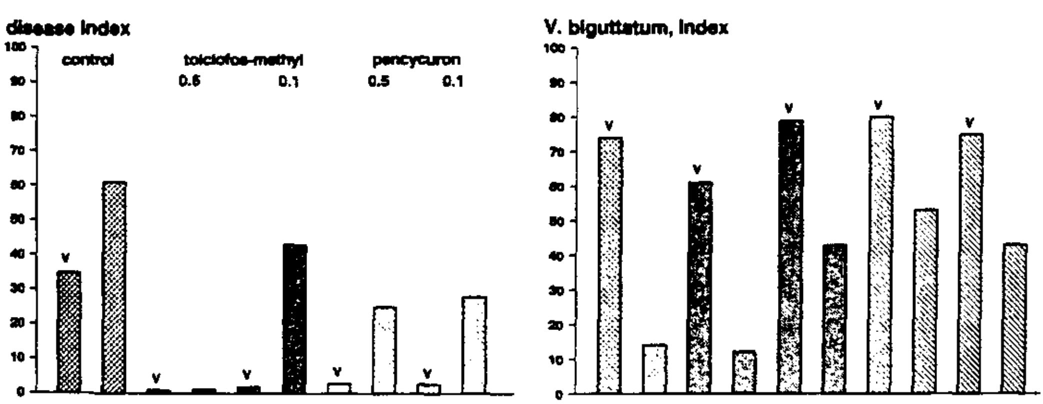

Figure 2. Effect of biological, chemical and integrated control on the disease index and the amount of *V. biguttatum* on sprouts (v = inoculated with *V. biguttatum*).

b3. Integrated control. This way of control was superior to chemical control with the *same* low rate of the fungicide. The improvement was often statistically significant, although the sv values were still too high (higher than 5%) in a few cases.

The effects of chemical and integrated control were plotted in Figure 3 in the same way as in Figure 1. Due to chemical control 56% of the fields had the required sv of less than 5%; for integrated control the figure was 81%. In 15 fields there were no losses. Different rates of fungicides were used. In Figure 4 the effects of chemical control with the recommended dose of Monceren is compared with the effect of integrated control with 1/4 Monceren. As far as may be concluded from this small number of points, there seems to be little difference between the effects of the two ways of control. However, most points lie below the line x = y, pointing to a slight superiority of chemical control with 1/1 Monceren.

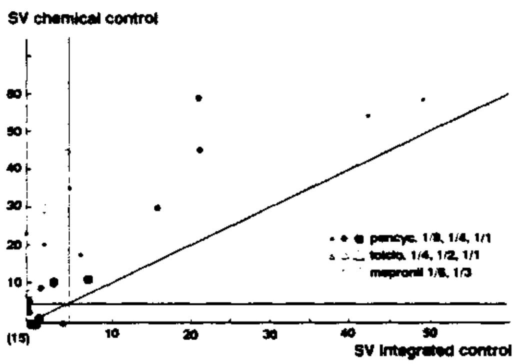

Figure 3. Chemical versus integrated control. Each point represents average values of one field.

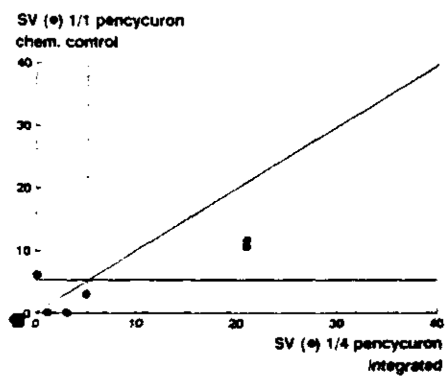

Figure 4. Effect of chemical control with 1/1 Monceren compared with integrated control with 1/4 Monceren.

4 DISCUSSION

Biological control can reduce losses due to grading to a level that does not exceed 5%, while integrated control with *V. biguttatum* and a low rate of a suitable fungicide is a further improvement and can be about as good as the effect of chemical control at the recommended rate application.

Integrated control markedly reduces the amount of fungicides needed. On neutral marine loams the amount can be reduced by about 75% or more, on slightly acid sandy soils by 50-75%.

It would be ideal if 3 or 4 fungicides could be used that affect *R. solani* in essentially different ways. If these fungicides would be used alternately, it is unlikely that the pathogen will develop tolerance or resistance. Similarly, accelerated biological decomposition of the fungicides is unlikely to occur.

Biological control failed in some fields on different soil types. The cause is known in an exceptional case only. In most cases the failure was probably caused by biological factors destroying conidia of *V. biguttatum*. This problem is being studied further.

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