Interactions Between Herbicides and Cotton Seedling Damping-off in the Field

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Abstract

We studied the impact of three pre-plant herbicides, trifluralin, pendimethalin and prometryn on the incidence and the development of Rhizoctonia solani-induced cotton seedling damping-off in the field. In a field experiment conducted in Safford, Arizona, pre-plant application of pendimethalin or prometryn but not trifluralin caused significant (P <0.05) increases in disease incidence. In another field experiment in Tucson, Arizona, significant (P <0.05) increase in disease incidence was observed in plots treated with prometryn and not in those treated with pendimethalin and trifluralin. In Tucson field experiment, application of herbicides also affected disease development as judged by the slope of disease progress curves.

Introduction

Environmental factors play important roles in the incidence and development of soilborne plant diseases (Agrios, 1988). Soil factors that can potentially affect soilborne plant diseases in the field include: moisture, temperature, texture, pH, soil atmospheric composition and presence of agricultural chemicals such as herbicides.

Herbicides are reported to affect the incidence and severity of plant diseases (Altman and Campbell, 1977; Altman and Rovira, 1989; El-Khadem and Papavizas, 1984; El-Khadem *et al.*, 1984; El-Khadem *et al.*, 1979; Rovira and McDonald, 1986). The cereal cyst disease caused by a nematode (Altman and Rovira, 1989), take-all of wheat caused by fungus *Gaeumannomyces graminis* var *tritici* (Rovira and McDonald, 1986) and sugar beet damping-off caused by fungus *Rhizoctonia solani* (Altman and Campbell, 1977) increased after application of herbicides trifluralin, chlorsulfuron and cycolate, respectively. Application of herbicides trifluralin and dinitramine to the field soil also increased cotton seedling damping-off caused by *R. solani* (El-Khadem *et al.*, 1979).

In contrast the incidence of cotton seedling disease caused by fungus *Fusarium oxysporum vasinfectum* decreased after application of trifluralin, dinitramine, fluometuron, diuron, dalapon and prometryn to the field soil , while the incidence of *R. solani*-induced cotton seedling damping-off was not significantly affected by these herbicides (El-Khadem *et al.*, 1984). Application of herbicides EPTC and linuron also decreased the incidence of post emergence but not pre-emergence cotton seedling damping-off (El-Khadem and Papavizas, 1984).

We investigated the impact of three widely used pre-plant herbicides, pendimethalin, prometryn, and trifluralin on the incidence and the development of *R. solani*- induced cotton seedling damping-off. The disease is important on cotton (Brown and McCarter 1976), often resulting in a substantial reduction in cotton stand.

Materials and methods

Herbicides used. Three herbicides, trifluralin (treflan) [2,6-dinitro-*N,N*-dipropyl-4-(trifluoromethyl)-benzenamine], pendimethalin (prowl) [*N*-(1-ethylpropyl)-3,4-dimethyl-2,6-dinitrobenzenamine], and prometryn (caparol) [*N,N*-bis(1-methylethyl)-6-(methylthio)-1,3,5-triazine-2,4-diamine] were tested in this study. These herbicides are currently registered for use as pre-emergence herbicides on many crops including cotton.

Field experiments. We established two field experiments, with plots arranged in a randomized block design, and managed them according to the procedures followed by cotton growers in Safford and Tucson, Arizona in April 1996. The soil at the Safford and Tucson experimental sites were loam soils containing 14% clay, 36% silt, 50% sand and 15.1% clay, 33.0% silt, and 51.9% sand, respectively. There were four treatments each with four replicates in each experiment. Each replicate plot was a 10-m long section of a bed. Beds were 100 cm apart. Trifluralin, pendimethalin or prometryn was sprayed in a 60-cm band on the top of each plot at the recommended field concentration using a CO_2-pressurized back pack sprayer. Herbicides were incorporated into the top 5 to 7 cm of soil with a rotomulcher shortly after application. Plots were infested with *R. solani* inoculum. according to the following procedures: One kg of barley seeds were wetted with 500 ml of water and autoclaved at 15 psi for 60 min. Seeds were inoculated with *R. solani* and incubated at 25 °C for three weeks. Seeds were air dried for 24 h and ground with a mill through a 3-mm sieve and were stored in a paper bag at 25-27 °C in the laboratory. Eight g of the fungal inoculum were mixed with 200 g of the field soil and sprinkled into the furrow of each 10-m-long replicate plot shortly before sowing. The incidence and the development of *R. solani*-induced cotton seedling damping-off were assessed by counting the number of emerged seedlings (stand count) in each plot 15, 25 and 50 days after planting.

Statistical analysis. The stand count data in herbicide-treated and untreated plots for two field experiments were analyzed by analysis of variances (ANOVA) and means were compared by Duncan multiple range test using COSTAT (Cohort Software, Berkeley, CA). Slopes of disease progress curves (change in stand or mortality over time) was determined by regression analysis using COSTAT. Slopes of disease progress curves for different treatments in each experiment were compared using procedures described by Campbell and Madden.

Results

On all sampled, non-emerged and emerged seedlings, typical *R. solani*-induced damping-off symptoms were observed in both field experiments. Radicles, roots and lower stems of all sampled seedlings yielded *R. solani* on PDA. Other cotton seedling pathogens were not recovered.

The cotton seedling damping-off incidence was affected by two of three test herbicides in both field experiments (Table 1-2). The stand count in plots treated with pendimethalin and prometryn in the Safford field experiment was significantly ($P < 0.05$) reduced by 29.6, 38.9, 46.7% and 27.2, 30.2, 39.1%, relative to the control (no herbicide), 15, 25 and 50 days after sowing, respectively (Table 1). The change in the stand count in plots treated with trifluralin in the Safford experiment was not significant ($P > 0.05$). The stand counts in plots treated with prometryn in the Tucson field experiment was significantly ($P < 0.05$) reduced by 40.6, 49.5 and 54.4% relative to the control, 15, 25 and 50 days after sowing, respectively (Table 2). Pendimethalin and trifluralin did not cause significant changes in the stand count in the Tucson field experiment.

Test herbicides also affected disease development in one field experiment as judged by the slopes of disease progress curves (Table 1-2). In the Tucson field experiment pendimethalin and trifluralin but not prometryn affected disease development significantly (Table 2). Disease development was not affected by any herbicide in the Safford experiment.

Discussion

It is concluded that pendimethalin and prometryn, that are currently being used on cotton, may cause significant (P <0.05) increases in the incidence of *R. solani* -induced cotton seedling damping-off in the field. These findings are in agreement with the results of previous studies on the effect of herbicides on the incidence and severity of some plant diseases including cotton seedling diseases (Altman and Campbell, 1977; Altman and Rovira, 1989; El-Khadem and Papavizas, 1984; Miller *et al.*, 1979; Moustafa-Mahmoud *et al.*, 1993; Rovira and McDonald, 1986).

We do not know how herbicides cause changes in damping-off incidence. The phenomenon could be due to the effect of herbicides on plant (Neubauer and Avizohar-Hershenson, 1973; Pinckard and Standifer, 1966), on pathogen (El-Khadem and Papavizas, 1984; El-Khadem *et al.*, 1984), on antagonistic microorganisms (Heydari *et al.*, 1997) and/or on the interactions among these entities. Herbicide-mediated changes in the plant may occur both at the physical and biochemical levels (Altman and Campbell, 1977).

Herbicides may affect pathogens directly (Altman and Campbell, 1977; El-Khadem *et al.*, 1984; El-Khadem *et al.*, 1979). Herbicides are reported to encourage (El-Khadem *et al.*, 1979) or discourage the pathogenic activity of *R. solani*. The effect could be stimulatory or inhibitory. For example, in *R. solani*-sugar beet combination, herbicide cycolate may interfere with the growth of the fungus and at the same time may enhance root exudates. In such cases, the impact of the herbicide on the disease is determined by the balance of stimulatory and inhibitory effects (Altman and Campbell, 1977). In our study, the growth of *R. solani* in vitro was not significantly affected by any of three test herbicides.

Alterations in the outcome of plant-pathogen interactions in the presence of herbicides may also be due to the effect of herbicides on naturally occurring microbial antagonists of pathogens (Katan and Eshel, 1973). Herbicides tested in this study caused a shift in bacterial communities in cotton rhizosphere including some biocontrol-active bacteria (Heydari *et al.*, 1997).

Trifluralin and prometryn effects on cotton seedling damping-off have been variable. For example prometryn which increased cotton seedling damping-off in this study did not change the incidence of this disease in a previous study (El-Khadem *et al.*, 1984). Moreover, trifluralin that has been reported to increase cotton seedling damping-off (Moustafa-Mahmoud *et al.*, 1993; Neubauer and Avizohar-Hershenson, 1973) did not affect the disease in our study and in a previous study (El-Khadem *et al.*, 1984). Differential responses may be due to the differences in soil moisture, soil temperature, herbicide concentration, *R. solani* races, cotton varieties, the composition of rhizosphere microflora and the rate of herbicide inactivation. The development of tolerance to herbicides by pathogens as a result of long-term herbicide use may also be responsible.

Results of the present study provide additional evidences that a pesticide which is being used against a specific pest may encourage the activity of another pest and argue in favor of Integrated pest management (IPM) strategies for managing pest problems. However, the selection of an ideal pesticide (one which is not harmful to the crop and to non-target beneficial organisms) is difficult because of the number and diversity of pests involved in any crop in a region. For example, in addition to insects and weeds, cotton seedlings are damaged by a number of soilborne pathogens besides *R. solani*. Although *R. solani*-induced cotton seedling damping-off was shown in this study to increase in the presence of pendimethalin and prometryn, it is not known how other soilborne cotton diseases respond to these herbicides. The development of IPM requires a knowledge of the impact of a selected pesticide not only on its intended target but also on plants as well as on beneficial and harmful microorganisms and insects.

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Table 1. Plant stand for soils treated with each test herbicide and infested with *Rhizoctonia solani* inoculum at the Safford field experiment.

Treatment	Plant stand						Slope[x]
	15 days		25 days		50 days		
	Stand[y]	% change[z]	Stand	% change	Stand	% change	
R. solani only	166 a	-----	126 a	-----	105 a	-----	-30.55
R. solani + pendimethalin	117 b	-29.6	77 b	-38.9	56 b	-46.7	-30.25
R. solani + prometryn	121 b	-27.2	88 b	-30.2	64 b	-39.1	-28.25
R. solani+ trifluralin	163 a	-1.9	132 a	+4.7	112 a	+6.6	-27.85

[x] Slopes of disease development curves (change in plant stand over time). Slopes marked with asterisks are statistically different from that of control (*R. solani* only) according to the procedures described by Campbell and Madden.
[y] Stand is represented as mean (the number of emerged seedlings in one plot sown with 400 seeds). Each mean is an average of four replicates. Means followed by the same letter in each column are not significantly different according to the Duncan multiple range test ($P > 0.05$).
[z] Represents % change in plant stand relative to the control (*R. solani* only).

Table 2. Plant stand for soils treated with each test herbicide and infested with *Rhizoctonia solani* inoculum at the Tucson field experiment.

Treatment	Plant stand						Slope[x]
	15 days		25 days		50 days		
	Stand[y]	% change[z]	Stand	% change	Stand	% change	
R. solani only	101 a	-----	87 a	-----	79 a	-----	-10.75
R. solani + pendimethalin	91 a	-9.9	75 ab	-13.8	55 ab	-30.4	-18.13*
R. solani + prometryn	60 b	-40.6	44 b	-49.5	36 b	-54.4	-12.15
R. solani+ trifluralin	104 a	+2.9	97 a	+11.4	70 a	-11.4	-28.95*

[x] Slopes of disease development curves (change in plant stand over time). Slopes marked with asterisks are statistically different from that of control (*R. solani* only) according to the procedures described by Campbell and Madden.
[y] Stand is represented as mean (the number of emerged seedlings in one plot sown with 400 seeds). Each mean is an average of four replicates. Means followed by the same letter in each column are not significantly different according to the Duncan multiple range test ($P > 0.05$).
[Z] Represents % change in plant stand relative to the control (*R. solani* only).