Effects of Herbicides on Root Rot of Pinto Bean, Weeds, and Two Soilborne Fungi

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ABSTRACT

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Under low and moderate disease severity in the field, herbicides did not significantly increase or decrease pinto bean root rot caused by *Fusarium solani* f. sp. *phaseoli* and *Rhizoctonia solani*. Treatments that included minimal (EPTC), moderate (EPTC plus trifluralin), and intensive (alachlor, EPTC, and trifluralin) levels of herbicides generally decreased weed populations in proportion to herbicide level but had no effect on soil population densities of *F. solani* or *R. solani* and little effect on bean yields.

Bean root rot is a disease complex caused by several fungi, including *Fusarium solani* f. sp. *phaseoli* (Burk.) Snyd. & Hans., *Rhizoctonia solani* Kühn, *Aphanomyces euteiches* Drechs. f. sp. *phaseoli* Pfend. & Hag., and *Pythium* spp. (2,5,10,13). In irrigated dry bean regions of Colorado and Nebraska, *F. solani* f. sp. *phaseoli* is the primary causal agent of bean root rot (5,13). Keenan et al (5) reported an 84% reduction in dry bean yield in some fields attributable to the disease in 1971 in Colorado.

Several reports have indicated that bean root rot can be enhanced or reduced by certain herbicides. Altman (1) reported bean root rot caused by *F. solani* f. sp. *phaseoli* was increased by trifluralin and EPTC, and Walker (15) found that trifluralin increased disease severity by this pathogen in field and greenhouse studies in Colorado. Quakenbush and Wilson (11) found, however, that EPTC and trifluralin did not increase bean root rot in field studies in Nebraska. With intensive use of herbicides becoming more prevalent, particularly with conservation tillage systems, the effects of herbicides on plant diseases and other crop production parameters need to be known.

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A 4-yr study on the use of four weed management systems in a barley (*Hordeum vulgare* L.), corn (*Zea mays* L.), pinto bean (*Phaseolus vulgaris* L.), and sugar beet (*Beta vulgaris* L.) rotation was conducted between 1981 and 1984 to determine the effects of herbicide levels on a number of crop paramenters. Within this study, we focused on the effects of herbicide levels used for pinto bean on the severity of bean root rot and soil population densities of *F. solani* and *R. solani*. Additionally, the effects of these herbicide levels on bean yield and weeds were determined.

MATERIALS AND METHODS

Field studies were initiated in 1981 at Windsor, CO, and concluded in the fall of 1984. In 1980, the entire experimental site was planted to field corn, and in 1981, the site was divided into four fields that were planted with either barley, field corn, pinto bean, or sugar beet to initiate a rotation sequence with these crops. This rotation sequence then was followed in each field for the next three seasons. In 1982, a moderate level of bean root rot was found in the pinto bean field; our laboratory and field study on bean root rot was conducted in 1983 and 1984. In the 1983 field, beans were preceded by corn, barley, and corn, and in 1984, beans were preceded by corn, barley, sugar beet, and corn.

Herbicides were applied preplant, with the exception of EPTC in the intensive treatment, which was applied just before vining and immediately after the final field ditching operation in early July (layby). Treatments were: untreated control; minimal level, EPTC at 3.4 kg/ha; moderate level, EPTC at 2.8 kg/ha plus trifluralin at 0.6 kg/ha; and intensive level, alachlor at 2.8 kg/ha plus trifluralin at 0.6 kg/ha, then EPTC at 3.4 kg/ha layby. Pinto beans (cultivar Olathe) were planted in late May of each year according to standard agronomic practices. Treatment plots consisted of 12 rows, each 61 m long. Experimental design each year was a randomized complete block with four replicates. Plots were furrow-irrigated as needed throughout 1983 and 1984.

Bean plants were evaluated for root rot in mid-August of both years. Twenty plants were sampled from each plot by randomly digging five plants from rows 3, 5, 7, and 9. Soil was shaken from roots, excised root systems were placed in plastic bags, and samples were taken to the laboratory for rating. Root systems were washed in running tap water for 2 min and rated for root rot severity on a scale of 0–5, where 0 = completely clean hypocotyl and root system and 5 = plant dead from root rot (11). Isolations were made from the hypocotyls (two 1-cm sections each) from each plant sample in both years. Sections were surface-disinfested in 0.6% sodium hypochlorite solution for 5 min and blotted on paper towels. One section from each plant was plated on acidified potato-carrot agar (PCAL) (14), and the other section was plated on Komada's *Fusarium*-selective medium (KM) (7). All plates were incubated for 4–7 days under continuous fluorescent light at 23 C, and fungal colonies were either directly identified or subcultured on PCAL for identification. PCAL served as an excellent medium for identifying *Fusarium* spp. and as a general growth medium for *R. solani*.

In late August of each year, weed control was assessed before harvest. Weeds were counted in eight random quadrats, each 17 cm wide and 150 cm long, per plot. Beans were harvested from the inner eight rows of each plot. Foreign materials and split seeds were determined and adjusted bean yields calculated.

After harvest, the field was plowed and disked, and soil samples were taken. Twenty 2-cm cores from each plot were taken along a specific grid pattern to a 30-cm depth with a soil sampler and composited. Soil samples were passed through a 6-mm-mesh screen, and the soil was thoroughly blended for 2 min. Subsamples were taken and stored at 5 C. Population densities of *F. solani* were determined by the dilution plate technique (4). Dilutions of 1:500 were plated on KM, and plates were incubated under

continuous room light for 5–7 days. Colonies of *F. solani* were directly identified and counted on KM (based on typical cultural characteristics), or colonies were subcultured on PCAL and identified, based on microscopic examination for typical macroconidia and microconidia and chlamydospores of *F. solani*. Population densities of *R. solani* were determined with a soil-pellet sampler (3) and Ko and Hora's *Rhizoctonia*-selective medium (6). Petri plates were kept at 23 C under continuous room light for 18 hr, and colonies were counted.

For each of the variables (bean root rot severity, weed and fungal population densities, and yield), the following procedure was used: An analysis of variance was performed incorporating the effects of treatment, year, and replicate nested within year. Residuals from the fitted model were tested for normality with a Shapiro-Wilk W-statistic (12); in no case was the hypothesis of normality rejected at $P = 0.10$. Consequently, no transformation of the data was deemed necessary. Where the *F*-statistic was significant, means were separated by Duncan's multiple range test.

RESULTS AND DISCUSSION

Based on overall disease severity ratings (DSIs), treatment means for bean root rot were moderate in 1983 (DSI = 2.5–3.2) and low in 1984 (1.4–1.5); overall ratings in 1983 were significantly greater than in 1984. There were no significant differences in DSIs for any herbicide treatment in 1983 or 1984 (Table 1). In 1983, the greatest DSIs occurred in plots with moderate and intensive herbicide levels; however, these DSIs were not significantly different from the untreated control (Table 1). These results agree with those of Quakenbush and Wilson (11), who reported no increase in bean root rot (probably caused by *F. solani* and *R. solani*) after application of EPTC (3.4 kg/ha) or EPTC plus trifluralin (2.2 and 0.6 kg/ha, respectively) in Nebraska. Their study was conducted in the field with naturally occurring inoculum and bean cultivar Great Northern UI 59. Other reports indicating that EPTC and trifluralin can increase bean root rot often were conducted with exceptionally high inoculum levels in the greenhouse or environmental chambers (1,15–17); few field studies have shown increased bean root rot attributed to herbicides (16). In a field study conducted in Wisconsin, Hagedorn and Binning (2) found that trifluralin had no effect or slightly decreased root and hypocotyl rot of snap beans caused by *Pythium ultimum* and *Aphanomyces euteiches* f. sp. *phaseoli*. Obviously, herbicides may influence different pathogens in different ways, and it is important to determine which pathogens are responsible for the disease in different regions.

Fifty-eight and 83% of bean hypocotyls plated on PCAL in 1983 and 1984 yielded *R. solani* and 83 and 88% yielded *F. solani*, respectively. Seventy-five and 88% of hypocotyls plated on KM yielded *F. solani* in 1983 and 1984, respectively. There were no significant differences in isolation frequencies of these fungi from treatment plots in either year. The results agree with other reports that *F. solani* and *R. solani* are the primary pathogens involved with bean root rot in irrigated dry beans in Colorado and Nebraska (5,13).

There were no significant differences in population densities (PDs) of *F. solani* or *R. solani* among treatments in 1983 or 1984. PDs of *F. solani* ranged from 417 to 833 colony-forming units (cfu) per gram of soil in 1983 and from 209 to 375 cfu in 1984. PDs of *R. solani* ranged from 3.7 to 4.8 and from 2.4 to 3.1 cfu in 1983 and 1984, respectively. Significantly greater fungal PDs of both fungi were recovered in 1983 than in 1984. The higher DSIs in 1983 may be related to the higher overall PDs of the fungi in 1983.

Although we found no effect of herbicides on bean root rot with low and moderate levels of disease, further study is warranted in fields where high levels of natural inoculum exist, i.e., 1,000–3,000 cfu of *F. solani* f. sp. *phaseoli* (9). Under these conditions, herbicides may enhance bean root rot, though Maloy and Burkholder (8) concluded that relatively low PDs of *F. solani* may induce a high incidence of infection in the field. In our study, PDs of *F. solani* ranged from 209 to 833 cfu/g of soil, presumably only part of which were *F. solani* f. sp. *phaseoli*; thus, there was not a high level of inoculum in our fields. High levels of inoculum develop in fields after 2 yr or more of continuous bean culture (10); both fields used in our study had not had beans grown for at least 3 yr (1983) or 4 yr (1984). Because most bean growers in Colorado practice crop rotation, however, our fields were considered representative of most growers' situations.

There were no significant differences in bean yields in treatment plots in 1983 (Table 1). In 1984, bean yields were significantly lower in the intensive herbicide treatment than in the minimum and moderate treatments. Yield from the intensive treatment was not significantly different from the untreated control (Table 1). Yield losses were not attributed to bean root rot in either year, and the yield decrease in the intensive regime in

Table 1. Root rot severity and yield of pinto bean grown at four herbicide levels[w]

Herbicide level[x]	1983 DSI[y]	1983 Yield[z] (kg/ha)	1984 DSI	1984 Yield (kg/ha)
Untreated	2.5 a	2,770 a	1.5 a	1,930 ab
Minimal	2.9 a	2,730 a	1.5 a	1,960 a
Moderate	3.2 a	2,560 a	1.4 a	2,000 a
Intensive	3.2 a	2,610 a	1.4 a	1,790 b

[w] Means followed by the same letter are not significantly different at $P = 0.05$ according to Duncan's multiple range test.
[x] Minimal = preplant-incorporated (ppi) EPTC at 3.4 kg/ha; moderate = ppi EPTC at 2.8 kg/ha plus trifluralin at 0.6 kg/ha; and intensive = ppi alachlor at 2.8 kg/ha plus trifluralin at 0.6 kg/ha, followed by EPTC at 3.4 kg/ha layby.
[y] DSI = disease severity index visual rating system on a scale of 0–5, where 0 = clean hypocotyl and root system and 5 = plant dead from root rot; means of four replicates, with 20 samples per replicate.
[z] Yield = adjusted mean yields based on four replicates, with eight 61-m rows per replicate.

Table 2. Late-season weed densities in pinto bean fields under different herbicide levels

Herbicide level[x]	Plants per hectare × 1,000[y] 1983 Total	1983 Broadleaf[z]	1983 Grass[z]	1984 Total	1984 Broadleaf	1984 Grass
Untreated	86.6 a	17.2 a	69.4 a	5.9 a	3.0 a	3.0 a
Minimal	50.6 b	13.7 a	36.9 b	10.2 a	4.3 a	5.9 a
Moderate	16.7 bc	4.0 b	12.6 c	4.0 a	1.9 a	2.2 a
Intensive	2.4 c	1.9 b	0.5 c	2.4 a	1.6 a	0.8 a

[x] Minimal = preplant-incorporated (ppi) EPTC at 3.4 kg/ha; moderate = ppi EPTC at 2.8 kg/ha plus trifluralin at 0.6 kg/ha; and intensive = ppi alachlor at 2.8 kg/ha plus trifluralin at 0.6 kg/ha, followed by EPTC at 3.4 kg/ha layby.
[y] Means within columns followed by the same letter are not significantly different at $P = 0.05$ according to Duncan's multiple range test.
[z] Major broadleaf weeds were *Amaranthus retroflexus* L., *Chenopodium album* L., *Kochia scoparia* (L.) Schrad., *Euphorbia dentata* Michx., nightshade (*Solanum* spp.), *Solanum rostratum*, and *Portulaca oleracea*; grass weeds were *Echinochloa crus-galli* (L.) Beauv., *Setaria glauca* (L.) Beauv., and *S. viridis* (L.) Beauv.

1984 may have been a direct effect of herbicides on plant growth. The lower overall yields in 1984 probably were due to hail damage, which resulted in defoliation and damaged pods. Thus, a number of factors can influence yield, and the more favorable growing conditions in 1983 overcame the moderate amount of root rot observed in this field.

There were fewer weeds in the moderate and intensive treatments in 1983 but not in 1984, and there were more weeds in all treatments in 1983 (Table 2). In 1983, there were more grass weeds in the untreated plots than in minimal herbicide plots, whereas minimal plots had more grass weeds than moderate and intensive plots (Table 2). More broadleaf weeds occurred in untreated and minimum herbicide plots than in moderate and intensive plots. Despite these weed differences, fungal PDs were not significantly different for any treatment, indicating no detectable influence of weed population on fungal PDs. Had there been a direct effect of herbicides on fungal PDs, which may have been masked by the difference in weeds in 1983, it is likely this would have been seen in 1984, when weed populations were not significantly different among treatments.

Within an integrated pest management study using different herbicides and crop rotations, herbicide levels (untreated, minimal, moderate, and intensive) did not significantly increase bean root rot caused by *F. solani* and *R. solani*. Thus, despite reports linking EPTC and trifluralin to increased bean root rot, it appears that growers with low to moderate root rot potential can use these herbicides without increasing losses from the disease.

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