EFFECT OF PREVIOUS CROPPING ON VERTICILLIUM DAHLIAE CONTROL AND POTATO PRODUCTION[1]

by
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ABSTRACT

Starting in 1982, plots were cropped for two consecutive years to potatoes, and the Verticillium dahliae-immune crops of field corn, sweet corn, sudangrass, spring wheat or spring wheat plus late-season sudangrass. Cropping had no effect on soil propagules of V. dahliae. In 1984, all plots were planted to potatoes. Previous cropping to immune crops, except spring wheat plus sudangrass, resulted in significantly fewer stem propagules of V. dahliae in the 1984 potatoes compared with previous cropping to potato. Plant height and yields of potato were also increased by previous cropping to immune crops other than potatoes. Plots previously cropped to sudangrass had more Verticillium wilt than any other cropping. None of the cropping treatments had significant effects on % U.S. No. 1 tubers. In 1985, plots were re-cropped as in 1982 and 1983. In the spring of 1986, one-half of each plot was fumigated and all plots were planted to potatoes. No cropping or fumigation treatment significantly affected soil propagules of V. dahliae. Fumigated plots in all cropping treatments, except those with spring wheat, had significantly fewer propagules in potato stems than nonfumigated plots. Verticillium wilt was significantly decreased and % U.S. No. 1 tubers were significantly increased by fumigation. Percentage of U.S. No. 1 tubers was significantly less in nonfumigated plots previously cropped to sudangrass, spring wheat, and spring wheat plus sudangrass compared with nonfumigated plots of field corn, sweet corn and potato. In 1986, previous cropping had no effect on Verticillium wilt. Plots previously cropped to potato and fumigated produced significantly lower yields than any other fumigated or nonfumigated cropping treatment.

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INTRODUCTION

For many years, crop rotation was the only means available to reduce losses from soil borne disease organisms such as Verticillium dahliae Kleb. In the 1960's, when soil fumigation became available, crop rotation was considered a less effective control. Long croppings of hosts immune to V. dahliae were thought necessary to produce worthwhile reductions V. dahliae. It was recently demonstrated that even one year of cropping with green peas followed by sudangrass usually reduced V. dahliae and maintained potato production (7). Growing of immune crops, such as alfalfa, barley, corn, grain sorghum, oats, paddy rice, perennial rye grass, reed canary grass, safflower, sudangrass, sugar beets and wheat compared with growing susceptible crops such as cotton, potatoes, and sunflower reduced Verticillium spp. in the soil and usually increased yields of the susceptible crops the following year (3,5,6,14,16,17,19,29).

In cases where immune alternate crops have failed to reduce Verticillium wilt in susceptible crops the following explanations have been proposed: 1) microsclerotia of V. dahliae were produced on roots of immune hosts (18,25,26); 2) the period of cropping immune host was too short (5); 3) the population density of Verticillium spp. propagules in soil was too high (6,19); 4) germination and sporulation of microsclerotia in the soil occurred repeatedly (11); and 5) there was failure to control susceptible weeds in immune crops (2,23,27,33).

Immune hosts have been defined as plants whose roots may be colonized but are not systemically infected by Verticillium spp. (10,24). In greenhouse culture, when massive number of Verticillim albo-atrum Reinke & Berth spores were used, it was possible to systemically infect grain sorghum (32). This organism could not be isolated from grain sorghum in naturally-infested field soil (32). Parasitic colonization of immune crop roots by Verticillium spp. doesn't appear to be a significant survival mechanism, at least in field soils (1). However, V. dahliae has been shown to colonize root surfaces of susceptible and resistant mint plants equally well (10,24). Microsclerotia of V. dahliae were stimulated to germinate in the rhizosphere and penetrate the roots of mint plants that were susceptible, resistant or immune to Verticillium wilt. Thus, although a host may not express wilt symptoms, they may not be immune to infection.

V. dahliae does not grow saprophytically through field soil (22). Only very low saprophytic colonization occurred after germination of microsclerotia adjacent to an organic substrate (crop residues) (1,26). Conidia and mycelia of V. dahliae survive only a short time in natural soil and, therefore, this fungus overwinters primarily in microsclerotia (15). Microsclerotia have been reported to increase by the formation of secondary microsclerotia (9). It has been suggested that sporulation occurs following germination of microsclerotia in the soil (24,28). However, Emmatty and Green (9) were unable to demonstrate sporulation.

The microsclerotium of V. dahliae is a heterogenous structure composed of cells which vary in pigmentation and, probably, cell wall thickness. They are subject to soil fungistasis (9) and are inhibited from germinating in the soil (31). They germinate either in the rhizosphere of plants or in association with root exudates. Fungistasis is reversed when the soil is amended with various sugars and amino acids (9). Root extracts of immune hosts apparently can stimulate germination of dormant microsclerotia. This overcomes natural soil fungistasis and reduces V. dahliae in the soil that may damage subsequent susceptible crops (31).

Water leaching of microsclerotia inhibits germination (9). However, when leaching is discontinued germination occurs. Germination apparently requires endogenous nutrient reserves that are removed by leaching. Farley et al. (11) reported germination and sporulation after nine consecutive periods of air-drying and remoistening of microsclerotia in soil. They concluded that propagules responsible for population increases were not secondary microsclerotia (9), but conidia formed by germination of microsclerotia in soil. Fitzell et al. (12) observed only microsclerotia germinating in rhizosphere soil around the root cap. In infected plant tissues, the fungus spreads in the vascular system by movement of conidia (13).

In the laboratory, V. dahliae grew, sporulated, and formed microsclerotia under relatively dry conditions (20). In wet soils, low concentrations of O_2 and high concentrations of CO_2 decreased production of V. dahliae microsclerotia (21). Bacterial antagonists may inhibit V. dahliae in wet soils (4).

Alternate cropping to sudangrass maintains potato yields and tuber quality similar to soil fumigation (7). This paper compares cropping of sudangrass to cropping with other immune V. dahliae hosts such as spring wheat, sweet corn,and field corn and spring wheat followed by sudangrass.

MATERIALS AND METHODS

Starting in 1982, plots were cropped two consecutive years to field corn (Northrup King PX49 in 1982-83, Northrup King PX 9353 in 1985), sweet corn (Golden Jubilee), sudangrass (Piper), spring wheat (Fielder in 1982-83, Dirken in 1985), spring wheat plus sudangrass and potatoes (Russet Burbank). In 1984, all plots were planted to potatoes. In 1985, plots were recropped as in 1982 and 1983. In the spring of 1986, one-half of each plot was fumigated with methylbromide (400 lb/A), tarped and sealed. Nitrogen, 100 lb/A, was broadcast prior to plowing for all immune crops except for potato, which received 300 lb N/A. All plots were planted to potatoes. Plots were 30 ft wide by 20 ft long. Each treatment was completely randomized and replicated six times.

In 1984 and 1986, soil samples (10 cores 3/4 inch dia x 8 inches in depth/plot) were taken from the center of the potato hills from each plot and stored at 38°F until analyzed for V. dahliae. The soil sample from each plot was mixed, a 0.5 g sample taken, diluted 1:50 with water, shaken for one-half hour,and spread on culture medium (8). V. dahliae propagules were counted after a 10-day incubation in the dark at 73°F.

In 1984 and 1986, during the fall, 12-inch portions from the base of 10 stems/plot were randomly collected and air-dried at 78°F for several months prior to analysis for V. dahliae. These dried stems were ground in a Wiley Mill, screened through a 60-mesh screen, diluted 1:200 with sterile tap water, spread on culture media, incubated, and examined for propagules as described above.

The number of wilted potato plants per plot were counted on October 15, 1984 and September 4, 1986. One of the middle rows of each 5-row plot was harvested and weights of total and % U.S. No. 1 tubers were recorded.

In 1984, randomized complete block analysis and in 1986, split-plot analysis were utilized to determine the statistical significance of treatment differences.

RESULTS

In 1984 and 1986, the two years when all plots were planted to potatoes, neither previous cropping nor soil fumigation significantly altered the number of propagules of V. dahliae in soil samples collected either in the spring or in the fall (Table 1). In 1984, potato stems from plots previously planted to crops other than potato except spring wheat plus sudangrass had significantly fewer propagules of V. dahliae than stems from plots cropped previously to potato. In 1986, potato stems produced in fumigated plots in all treatments, except for cropping with spring wheat, had significantly fewer propagules than stems from nonfumigated plots.

In 1984, plant height and yields of potato were significantly increased in plots previously planted to crops other than potato than in plots previously planted to potato. Plots previously cropped to sudangrass had significantly more Verticillium wilt on potatoes than plots previously planted to other crops. No cropping treatment significantly affected % U.S. No. 1 tubers.

In 1986, previous cropping did not have a significant effect on the incidence of Verticillium wilt in the potato crop. However, wilt was significantly reduced and the yield of % U.S. No. 1 tubers was significantly increased by fumigation in all cropping treatments compared with nonfumigation of cropping treatments. Previously cropping to sudangrass, spring wheat, and spring wheat plus sudangrass significantly reduced % U.S. No. 1 tubers compared with cropping to potato not fumigated. Plots previously cropped to potato and fumigated yielded significantly less than nonfumigated plots cropped to potato and plots of any other fumigated or not fumigated cropping treatment.

DISCUSSION

Previous cropping to V. dahliae-immune crops compared with continuous cropping to potato had very little effect on number of propagules of V. dahliae in the soil. In general, these V. dahliae-immune crops reduced stem propagules and increased potato yields in 1984 but not 1986.

In 1984 and 1986, the amount of Verticillium wilt in these crops was about the same. Possibly the one year cropping in 1985 compared with two years cropping in 1982 and 1983 did not reduce some unknown factor or V. dahliae in soil enough to produce a yield difference in 1986.

In 1984, an early season plant growth response occurred on potato in plots cropped previously to the immune crops; plant height was greater by July 3 (Table 1). This effect wasn't apparent in the 1986 potato crop. In 1984, V. dahliae might have stunted the potato plants in the plots previously cropped to potatoes.

In 1986, straw amendments and root residue of the previous cropping of spring wheat, sudangrass, or spring wheat plus sudangrass along with daily sprinkler irrigation may have maintained too much soil moisture and reduced % U.S. No. 1 tubers (Table 1). In another experiment, plots irrigated at a high rate of irrigation had significantly fewer % U.S. No. 1 tubers than plots irrigated at a normal rate. However, incorporation of wheat and sudangrass straw (6 T each/A) at the two irrigation rates had no effect on % U.S. No. 1 tubers (Easton, G. D., unpublished).

The reduction in yield resulting from fumigation of plots previously cropped to potato was surprising. Possibly, fumigation with methyl bromide caused a biological imbalance that reduced nutrient uptake and yields. In previous studies when plots previously cropped to potato were fumigated with either DD-PIC[R] (25 gal/A) or Telone C-17[R] (27.5 gal/A) yields significantly increased more than similarly cropped nonfumigated plots (7).

Cropping with immune hosts such as corn, wheat, and sudangrass should serve as decoy crops whose root extracts cause microsclerotia to germinate and thereby reduce populations of V. dahliae (10,12). Results of this and a previous study (7) showed that after previous cropping to sudangrass and other immune hosts, potato plots have fewer propagules in stems and produce greater yields than plots previously cropped to potatoes. Results of this study indicate it may be necessary to grow such immune crops more than one year to obtain yield increases. If immune crops contain weeds susceptible to V. dahliae, this would likely reduce the yield increases (2,27,33).

Table 1. Previous cropping and soil fumigation on Verticillium dahliae and potato production in 1984 and 1986.

Previous cropping	Methyl bromide fumigation	*V. dahliae* propagules/g soil X 10^3 spring 1984	spring 1986	fall 1986	*V. dahliae* propagules/g stem tissue X 10^3 fall 1984	fall 1986	Plant height (cm) 3 July 1984	% Verticillium wilt plants 15 Oct 1984	4 Sept 1986	U.S. No.1 tubers 1984	1986	Yield cwt/A 1984	1986
Potatoes	yes	-[x]	0.0	0.2	-	18.8B	-	-	10B	-	89A	-	469B
Potatoes	no	0.4	0.04	0.04	119.0A[y]	61.6A	68B	59B	53A	61	81B	583C	580A
Sudangrass (SG)	yes	-	0.0	0.07	-	18.4B	-	-	15B	-	87A	-	636A
Sudangrass (SG)	no	0.04	0.05	0.1	30.2C	51.6A	73A	84A	55A	61	68C	711B	636A
Spring wheat (SW)	yes	-	0.1	0.0	-	35.3B	-	-	9B	-	85A	-	583A
Spring wheat (SW)	no	0.008	0.0	0.06	47.6C	35.6B	72A	46B	51A	71	70C	750AB	590A
SW + SG	yes	-	0.02	0.2	-	29.2B	-	-	8B	-	88A	-	585A
SW + SG	no	0.04	0.0	0.2	102.2AB	62.8A	74A	48B	47A	71	70C	796A	607A
Sweet corn	yes	-	0.009	0.0	-	16.4B	-	-	9B	-	89A	-	612A
Sweet corn	no	0.02	0.0	0.04	54.2BC	49.6A	71AB	61B	56A	65	77BC	730AB	592A
Field corn	yes	-	0.07	0.1	-	12.4B	-	-	9B	-	87A	-	641A
Field corn	no	0.04	0.0	0.1	33.8C	69.2A	74A	48B	49A	61	76BC	717AB	653A
		n.s.[z]	n.s.	n.s.						n.s.			

[x] Data not recorded.

[y] Vertical means with the same letter are not significantly different according to Duncan's Multiple Range Test (P=.05).

[z] N.S. = Means not significantly different.

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