ALTERNATE CROPPING WITH SUDAN GRASS FOR VERTICILLIUM WILT CONTROL IN POTATOES [1]

by
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ABSTRACT

Long rotations to crops other than potato to control the Verticillium wilt organism in potato are uneconomical. Soil fumigation maintain yields, but under intensified cropping of potatoes it is expensive and tuber quality is not maintained.

Control of the Verticillium wilt organism and potato production in soil previously cropped to sudan grass were compared with that in a soil monocropped to potatoes. Portions of a field seeded to sudan grass following a crop of green peas in the same growing season, were rototilled, plowed, and planted to potatoes the following year. Production on these portions were compared with other portions planted two successive years to potato. The experiment was repeated twice. Previous cropping to sudan grass did not reduce Verticillium wilt but did reduce by one-half the colonization of potato stems by the Verticillium wilt organism. This rotation also increased percent U.S. No. 1 tubers 10 to 20%, increased specific gravity .002 to .008, and increased yield over 100 cwt/A.

Additional fumigation of the soil previously cropped to sudan grass did not increase potato quality of production.

INTRODUCTION

The wilt incited by Verticillium dahliae causes yields to decline 20% or more and reduces grade and quality of tubers even after only two croppings of potatoes. It has been estimated that Verticillium wilt costs Washington growers $86 million annually in reduced production and fumigation costs.

Long rotations to nonsusceptible crops to control the Verticillium wilt organism in potato are either ineffective (2, 14, 15, 23) or not economical. Alfalfa, barley, bluegrass, carrot, corn, mung bean, field peas, wheat, sorghum and sugarbeets are considered nonsusceptible to V. dahliae (1, 13, 17, 18). Failure of these nonsusceptible crops to control Verticillium wilt has been attributed to microsclerotia of V. dahliae in soil. Microsclerotia survive for long periods (14, 15), retain high populations (3, 10, 12), colonize nonsusceptible crops or the weeds in nonsusceptible crops (9, 13, 17, 18, 19, 20), and multiply near organic matter to maintain enough energy to later infect susceptible hosts (11). A two-year rotation to corn was reported to increase potato yields and quality (22). This rotation probably prevented an inoculum build-up of V. dahliae and thus reduced disease.

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We and others have shown that soil fumigation will reduce Verticillium wilt and keep yields from declining in wilt infested soils resulting from repeated cropping to potato, however, tuber quality continues to deteriorate in spite of fumigation (5, 6, 7). The net return from fumigation has become marginal because of the more expensive fumigant mixtures and the higher rates per acre needed for wilt control compared to nematode control only.

This study of cropping of soils with sudan grass on Verticillium wilt was undertaken after observing that potato production and quality remained high the year following cropping to green peas plus sudan grass and after observing that fumigation of such soils did not increase production or quality.

METHODS AND MATERIALS

In 1976, due to a water infiltration problem with row irrigation in a field of Shano silt loam soil near Prosser, Washington, sudan grass, cultivar "Piper", was seeded the last of July following a crop of green peas. The sudan grass grew to about 8 ft tall and was rototilled under in November in preparation for growing potatoes the next year. The field had been cropped previously at least four times to potato.

In the spring of 1977 the field was chisel plowed 14 inches in depth, both crosswise and lengthwise, plowed 12 inches in depth, and packed with a Brillion [R] crows-foot plow packer. Plots 20 ft by 12 ft were fumigated with Telone C-17[R] (17% chloropicrin and 83% Telone II [R]) and Terr-O-Cide 54-45 [R] (54% methylene dibromide 45% chloropicrin) by shanks spaced 9 inches apart penetrating the soil to a depth of 9 inches. The soil was sealed with a smooth roller immediately after fumigation. About one month following fumigation, Russet Burbank potato was planted in the field. Each treatment was randomly replicated six times. The experiment was repeated in 1978 and 1979, except that in 1979 the test also included Telone C [R] (15% chloropicrin and 85% Telone [R]) applied by shanks and MC-33 [R] (66% methyl bromide and 33% chloropicrin) injected under a 4 mil black plastic tarp and sealed by burying the edges. Since recommended rates of the fumigants did not increase yield in 1977 and 1978, rates were doubled in 1979.

In 1979, one-half of a Verticillium infested field was cropped to potatoes and the other half to green peas plus sudan grass. In 1980, plots 20 ft by 12 ft were fumigated with DD-PIC (85% DD [R] and 15% chloropicrin) in each half of the field as previously described. Treatments were randomly located and replicated six times in each field. The entire field was planted to Russet Burbank potatoes in 1980. Data was collected on the incidence of wilt, Verticillium propagules colonizing stems by late September, and production. In 1980, Verticillium propagule assays involved cutting 12-inch portions from the base of 10 stems per plot and in 1981 6-inch portions were cut from the growing tips of 10 stems per plot. These defoliated stems were air dried, ground in a Wiley Mill, screened through a 60-mesh screen, diluted 1:200 (1980) and 1:50 (1981) with water, and spread on culture medium (4). Propagules were counted after 14 days' incubation in the dark at 21°C. In 1981, soil samples were collected, diluted with water 1:50, and a .3-ml aliquot was spread on culture medium (4). Propagules of Verticillium were counted after 14 days' incubation at 21°C.

In 1980, Russet Burbank potatoes were planted in strips, 30 ft in width, across a field and alternating with strips planted first to green peas and later to sudan grass. In 1981, plots 20 ft by 12 ft were fumigated with Telone C-17 in each strip. All treatments were replicated six times. In 1981, potatoes were planted over the entire field. Plots were observed and harvested in each of the 12 strips.

RESULTS

From 1977-1981, soil fumigants occasionally reduced Verticillium wilt but did not increase yields on soils previously cropped to field peas plus sudan grass (Tables 1 and 2). Doubling the rate of fumigants and injecting MC-33 under a sealed tarp reduced wilt but did not increase yield. Soil fumigants reduced Verticillium propagules in stems in 1980 and in soils in 1981 and increased yields, but did not increase tuber quality both years on soil previously cropped to potatoes (Table 2).

The previous cropping to field peas plus sudan grass itself did not decrease Verticillium wilt (Table 2). However, it did significantly decrease Verticillium propagules in soil in 1981 and those colonizing stems in 1980 (but not in 1981). This rotation also significantly increased yields and percent U.S. No. 1 tubers both years, and increased specific gravity in 1980.

DISCUSSION

Crop rotation to symptomless hosts of *V. dahliae* has been ineffective in controlling *V. dahliae* because of microsclerotia which remain in the soil (14, 15). In spite of this, we found that Verticillium propagules can be reduced and yields can be increased by alternate cropping of field peas with sudan grass. This agrees with reports that rotation to grain sorghum (a close relative of sudan grass) reduced Verticillium disease incidence and increased cotton lint yields (3). Another report indicates that a corn-potato rotation produces higher yields and specific gravity than a potato monoculture (22). Inoculum density of *V. dahliae* at the time a field is rotated to a nonsusceptible crop might influence the success of a crop rotation (12). Green (12) indicated the choice of rotation crops may be more important than the time interval between croppings of the susceptible crop. Of course, the control of susceptible weed hosts also influences the success of crop rotations (9, 18).

We found fewer Verticillium propagules in stems assayed in 1981 than 1980 (Table 2). Difference may be because of field and year variations but most likely were due to method of collection -- with fewer propagules at stem tips (1981) than at base of stems (1980).

The exact reasons for yield increases due to crop rotations are not known. In Russia, plowing under a green manure crop, such as mustard of alfalfa, was thought to stimulate the development of saprophytic microflora, including antagonists that inhibited *V. dahliae* in cotton wilt (8, 16, 21). Other reports suggest the benefits of crop rotation are probably unrelated to control of *V. dahliae* (15). Crop rotation influences soil structure, moisture, fertility and other variables that affect yields (15).

We plan to explore the possibility that a buildup of antagonists to *V. dahliae* occurs during cropping to sudan grass. We have already found that bacterial antagonists that we added to potato seed pieces before planting in Verticillium-infested soil will reduce Verticillium wilt and increase yields equal to a soil previously cropped to field peas plus sudan grass (Wadi, J. and G. D. Easton, unpublished data).

Lack of Verticillium wilt reduction in potato by previous cropping to field peas plus sudan grass may be explained by a late season reinfestation of *V. dahliae* (Table 2). Antagonists from a previous field pea plus sudan grass cropping may reduce or delay early infection of *V. dahliae*, however, the pathogen could reinfest into the soil by infested potato seed and by irrigation water (4) or foliage could be infected by wind-blown spores (24).

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Table 1. Effect of fumigation on Verticillium wilt and yield of Russet Burbank potatoes grown on soil cropped the previous year to field peas plus sudan grass.

Year	Fumigants[1]	Rate/ acre	% Verticillium wilt (plants)	Cwt/A
1977	Telone C-17	20 gal	38 AB[3]	530 A
	Terr-O-Cide 54-45	8 gal	29 AB	479 AB
	Untreated control		46 A	501 A
1978	Telone C-17	25 gal	20 B	552 A
	Terr-O-Cide 54-45	8 gal	22 B	457 A
	Untreated control		55 A	515 A
1979	MC-33[2]	960 lb	7D	646 AB
	Telone C	25 gal	46 AB	711 A
	Telone C	50 gal	39 C	624 AB
	Telone C-17	25 gal	46 AB	639 AB
	Telone C-17	50 gal	25 C	639 AB
	Terr-O-Cide 54-45	12 gal	43 AB	566 C
	Terr-O-Cide 54-45	24 gal	25 C	530 C
	Untreated control		57 A	646 AB

[1]All fumigants except MC-33 applied preplant with shank spaced 9 inches apart and 9 inches in depth.

[2]Injected under a sealed, black, 4-mil plastic tarp.

[3]Numbers followed by the same letter of the alphabet are not significantly different according to Duncan's Multiple Range Test at the 5% level for results of each separate year.

Table 2. Effect of previous cropping with soil fumigation on Verticillium wilt, yield and quality of Russet Burbank potato.

Year	Crop previous year[1]	Fumigant and (gal/a)	% Verticillium wilt[2] (plants)	10^3 Verticillium propagules per g soil 9/28	10^3 Verticillium propagules per g stem[3]	Cwt/A	% No. 1 tubers	U.S. Specific gravity
1980[4]	P	0	89A[5]	--[6]	135.3A	610B	57B	1.076B
	fp+sg	0	89A	--	64.0B	719A	67A	1.084A
	P	DD-PIC(25)	71B	--	65.3B	719A	59B	1.080B
	fp+sg	DD-PIC(25)	61B	--	58.7B	748A	62B	1.084A
1981	P	0	68A	2.2A	.12A	479B	49B	1.074A
	fp+sg	0	68A	1.2B	.06A	581A	70A	1.072A
	P	Tel.C-17(27.5)	43B	0.6C	.01A	668A	60B	1.076A
	fp+sg	Tel.C-17(27.5)	36B	0.5C	0A	653A	63A	1.075A

[1] Planted the previous year to: P=potatoes; fp + sg=field peas plus sudan grass.

[2] Percent showing wilt out of approximately 28 plants/20 ft row.

[3] Stems collected on October 21, 1980 and October 3, 1981. See text for method of assay.

[4] Treatment in adjacent fields and not randomized in the same field.

[5] Numbers followed by the same letter of the alphabet are not significantly different according to Duncan's Multiple Range Test at the 5% level for results of each separate year.

[6] Data not taken.