EFFECT OF ANNUAL SOIL FUMIGATION AND ANNUAL PREHARVEST VINE BURNING ON CONTROL OF VERTICILLIUM1/

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SUMMARY

Fumigation of soils each spring for a period of five years reduced the population of the Verticillium wilt organism in the soil and increased yield. Preharvest burning of vines, which destroyed the resting stage of Verticillium every fall for four years, increased yield after the second year of burning. A reduction in population of Verticillium in the soil could not be detected until after the third year of burning.

Soil fumigation each spring reduces the population of Verticillium a week or two after its application controls the organism, and thereby allows an annual increase in yield. Preharvest vine burning destroys most of the resting stage in the stems that would overwinter in the soil and infect next season's crop, but it does not destroy existing soil populations.

Preharvest vine burning in heavily infested fields may not be practical since the initial soil population of Verticillium may be too great to allow this method to be of value.

A preharvest vine burning program should be adopted before Verticillium starts reducing yields -- preferably the first time the field is cropped to potatoes.

Chemicals for soil fumigation for Verticillium wilt control cost $60 - $100 or more, whereas cost of preharvest burning of dead vines average $6 - $15 per acre, depending upon the weather conditions and dryness of vines.

INTRODUCTION

Losses in yield of the Russet Burbank variety due to the microsclerotial form of the Verticillium wilt organism are increasing in all production areas of the Columbia Basin in Washington, even in the early harvest areas near Pasco. Fumigation of soils infested with Verticillium has been reported to increase yield (1, 2, 3, 6, 8). Burning of vines infected with Verticillium before harvest for two years significantly increased yield compared to the nonburned control treatment (5).

Changes in soil population, control of the Verticillium wilt organism by soil fumigation and/or preharvest vine burning were investigated over a 5 year period. Preliminary results of 1966-1968 have been reported (5).

METHODS AND MATERIALS

The field chosen for this experiment had been cropped to dry land wheat until 1962 and then planted to alfalfa under irrigation. The soil was artificially infested with Verticillium albo-atrum

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1/ This investigation was made possible through grants by the Dow Chemical Company, Shell Chemical Company, and the Washington State Potato Commission.

by planting Verticillium inoculated potato seed pieces, in 1965. Successive crops of Russet Burbank potato were grown from 1966 to 1970 without further artificial infestation.

Two fumigation treatments, Telone + Picfume (20 +5 gal/A) and DD + Picfume (20 + 5 gal/A), were applied to the same plots each spring from 1966 to 1970 except that in 1966 Telone PBC (30 gal/A) was applied rather than DD + Picfume. Treatments were replicated 6 times randomly in plots 24 x 50 feet (8 rows wide). Infected vines died naturally, then were either beat with a vine beater or burned with a propane gas burner at less than 1 mph each fall from 1966 to 1969. Each year one row out of eight in each treatment was harvested for yield. The remaining tubers were allowed to freeze in the field.

Verticillium infection was measured by plating sections of potato stems on a streptomycin-ethanol agar at varying time intervals during 1968-1970 (7). Soil populations of Verticillium were measured throughout this period by a method previously described (4). Soil samples for propagule counts consisted of a composite sample of 18 soil probes (3/4 inch diameter by 10 inch depth) collected randomly from each treatment plot. Propagule counts were determined for each soil sample from three - 1:50 soil dilutions with three plate replications. (Three dilutions x three plate replications x six field soil sample replications = 54 plate counts per treatment.)

Analysis of variance and Duncan's Multiple Range Test were used to determine significant differences between means at the 5% level (tables 3 and 4).

RESULTS

Fumigation each spring from 1966 to 1970 reduced the number of Verticillium propagules in the soil compared to the nonfumigation treatments (table 1). Burning of vines before harvest in the fall of 1966 either with or without soil fumigation, in general, reduced the population of Verticillium each spring. Verticillium populations increased toward the fall of each season with both treatments. The percentage of stems infected with Verticillium was reduced by soil fumigation and preharvest vine burning (table 2). Verticillium wilt symptoms were significantly reduced each year following spring fumigation of infested soil (table 3). Preharvest burning of infected vines without soil fumigation did not significantly reduce the number of wilted plants in 1966, 1967 or 1968, but did in 1969 and 1970.

Fumigation before planting significantly increased yields each year, except in 1966 with the Telone + Picfume vine burning treatment and in 1970 with both fumigants compared to the not fumigated, burning treatment (table 4). Yields were significantly increased with preharvest vine burning treatment alone in 1968, 1969 and 1970, but not in 1967. Only in 1969 did the combination treatment of soil fumigation and preharvest vine burningproduce a significant yield increase compared to the fumigation and preharvest, vine beating treatment (i.e. DD + Picfume 793 cwt/A).

DISCUSSION

Fumigation of soils each spring reduced the population of Verticillium in the soil , delayed plant infection and plant wilt (early dying), and increased yield. Preharvest burning every fall of vines infested with the resting stage of the Verticillium wilt organism did not either reduce Verticillium in the soil, delay plant infection or delay plant wilt until after the third year of vine burning and increase yield until after second year of vine burning. Within a week or two after its application, soil fumigation reduces the population of Verticillium present in the soil and thereby allows an annual increase in yield. Preharvest vine burning destroys most of the resting stage infesting the stems that would over-winter and infect the next season's crop, but does not destroy existing propagules in the soil. Annual vine burning probably prevents increases from the initial Verticillium population levels rather than reducing this level. This is evidenced by the fact that potato yields following annual vine burning were nearly stable over six seasons, whereas yields were, in general, progressively reduced each year in absence of any control (table 4).

Preharvest vine burning alone in heavily infested fields may not be practical since the initial

soil population of Verticillium may be too great to allow this method to be of value. Under this circumstance it is necessary to fumigate for one or two seasons before preharvest vine burning will provide adequate control.

The ideal time to initiate a preharvest vine burning program is before Verticillium starts reducing yields -- preferably the first time the field is cropped to potatoes.

Chemicals for soil fumigation for Verticillium wilt control cost $60-$100 or more per acre, whereas cost of preharvest burning of dead vines averages $6-$15 per acre, depending upon the weather conditions and dryness of vines.

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Table 1. Effect of annual fumigation and annual preharvest vine treatment on population of Verticillium propagules in infested soil.

Fumigants and gal/A[1]	Vine treatment[2]	Mean estimate of Verticillium propagules per gram of oven dry soil[3]												
		1968			1969					1970				
		Mar 14	Apr 10	Oct 18	Apr 7	May 2	June 18	July 29	Aug 26	Mar 10	Apr 22	June 18	July 27	Aug 19
Telone + Picfume (20 + 5)	beating	172	138	1222	0	0	17	48	214	348	0	17	34	32
"	burning	86	9	4245	0	3	0	31	251	219	0	3	0	0
DD + Picfume (20 + 5)	beating	243	330	1632	0	18	64	192	204	441	3	7	15	218
"	burning	101	0	996	0	7	31	29	2687	271	0	6	0	12
Not fumigated	beating	631	1066	959	11	916	253	278	537	381	163	129	1018	277
Not fumigated	burning	1801	1684	1355	0	17	159	357	608	245	16	73	32	592

[1] Fumigants applied on Mar. 30, 1966; Mar. 23, 1967; March 25, 1968; Apr. 9, 1969; and Apr. 1, 1970.

[2] Vine treatments applied to potato vines before harvest in falls of 1966, 1967, 1968, and 1969.

[3] Fifty-four plate counts per treatment mean.

Table 2. Effect of annual fumigation and annual preharvest vine treatment on infection by Verticillium in infested soil.

Fumigants and gal/A[1]	Vine treatment[2]	Mean per cent stems with Verticillium albo-atrum (microsclerotial type)[3]							
		1968	1969			1970			
		Sept 10	June 19	July 23	Aug 26	June 30	July 22	Aug 10	Sept 9
Telone + Picfume (20 + 5)	beating	74	1	3	46	0	3	0	15
"	burning	19	0	2	4	0	1	0	3
DD + Picfume (20 + 5)	beating	62	0	5	33	0	0	1	13
"	burning	23	0	0	6	0	1	1	2
Not fumigated	beating	33	16	40	75	35	23	14	30
Not fumigated	burning	53	2	25	66	4	5	4	12

[1] Fumigants applied on Mar. 30, 1966; Mar. 23, 1967; Mar. 25, 1968; Apr. 9, 1969; and Apr. 1, 1970.

[2] Vine treatments applied to potato vines before harvest in falls of 1966, 1967, 1968, and 1969.

[3] A total of 100 stems were collected randomly from the 6 replications of each treatment.

Table 3. Effect of annual fumigation and annual preharvest vine treatment on Verticillium wilt of potato grown in infested soil.

Fumigants and gal/A[1/]	Vine treatment[2/]	Mean no. of wilted plants[3,4/] Sept.12, 1966	Sept.7, 1967	Sept.10, 1968	Sept.3, 1969	Sept.3, 1970
Telone + Picfume (20 + 5)	beating	0 b	0 b	15 b	1 c	1 c
"	burning	0 b	0 b	4 c	.3 c	0 c
DD + Picfume (20 + 5)	beating	0 b	0 b	9 b	2 c	0 c
"	burning	0 b	0 b	2 c	0 c	0 c
Not fumigated	beating	6 a	21 a	34 a	30 a	27 a
Not fumigated	burning	5 a	13 a	32 a	23 b	15 b

[1/] Fumigants applied in springs of 1966, 1967, 1968, 1969, and 1970.

[2/] Vine treatment applied to potato vines before harvest in falls of 1966, 1967, 1968, and 1969.

[3/] Number of plants from a total of about 34.

[4/] Means followed by the same letter are not significantly different at the 5% level according to Duncan's Multiple Range Test.

Table 4. The effect of annual fumigation and preharvested vine treatment on yield of potato grown in Verticillium infested soil.

Fumigants and gal/A[1]	Vine treatment[2]	Mean yield (cwt/A)[3]				
		1966	1967	1968	1969	1970
Telone + Picfume (20 + 5)	beating	639a	629a	692a	735ab	600ab
"	burning	575bc	580a	711a	750ab	653ab
DD + Picfume (20 + 5)	beating	639a[4]	557ab	735a	706b	609ab
"	burning	595ab[4]	605a	750a	793a	624ab
Not fumigated	beating	546c	450c	522c	377d	464c
Not fumigated	burning	546c	488bc	605b	537c	566b

[1] Fumigants applied in springs of 1966, 1967, 1968, 1969, and 1970.

[2] Vine treatment applied to potato vines before harvest in falls of 1966, 1967, 1968, and 1969.

[3] Means followed by the same letter are not significantly different at the 5% level according to Duncan's Multiple Range Test.

[4] Telone PBC (30 gal/A) applied rather than DD + Picfume.