LACK OF EARLY BLIGHT CONTROL BY AIRCRAFT-APPLIED FUNGICIDES ON SPRINKLER IRRIGATED POTATOES [1]

by

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SUMMARY

Early blight control by aircraft application of fungicides on 18 farms growing potatoes under sprinkler irrigation was monitored from 1972 through 1974. The number of early blight lesions on leaves was not reduced nor did a significant increase in yield or % U.S. No. 1 tubers result from any of the fungicide programs involving various fungicides and numbers and dates of application compared to no program.

Spores of the early blight fungus, Alternaria solani, were trapped near the soil surfaces in all potato fields throughout the growing seasons, but spores were seldom trapped above the plants until late in the season. No spores were trapped westward of these fields, the source of most prevailing winds.

Early blight lesions on leaves increased in numbers from June to September all three years. Very few colonies of A. solani were isolated from symptomless areas of leaflets during this same period, indicating that little infection occurred without lesion development.

INTRODUCTION

Early blight caused by A. solani (Ell. and Martin) Jones and Grout was first described by Ellis and Martin in 1882 on dying leaves of potatoes in New Jersey (28). Tuber rot caused by this organism was overlooked until 1925 (3).

Leaflets infected by early blight develop characteristic oval or angular leathery "target patterned" lesions. Infection is greater and more lesions develop as the host plant physiologically matures (2, 24).

Primary inoculum for initial foliage infection may be either dormant mycelia in leaves (28) or spores originating from debris dposited in the soil from a previous crop (8, 19). Secondary inoculum is thought to be spores from primary leaf lesions (8).

Wind is reported to be the spore disseminating agent (8, 22). However, high winds over a period of days will diminish the number of air-borne spores (22). Large numbers of spores are

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usually formed at night under cool moist conditions, but are not dispersed until leaves dry and winds increase in the morning and afternoon (8, 22). Dew, rain or sprinkler irrigation water is necessary for infection (4, 6, 21, 22, 23).

Infection by A. solani is direct through stem and leaf cuticle (28). Work in Colorado showed that leaflet infection occurred in early spring, but that disease symptoms were delayed for 1 mo. (8), indicating temporary field resistance or tolerance to symptoms in young foliage (26). Initial leaf lesions developed in the lower, chlorotic, senescent leaves, even though isolations showed that younger leaves are frequently infected (8).

Early blight is usually controlled by application of fungicides to the potato foliage to prevent infection (7, 9, 11, 12, 17, 18). In Colorado, early blight was controlled under row and sprinkler irrigation by a ground sprayer applying approximately 100 gal of fungicide solution per acre. However, yield increases seldom occurred in treated plots because the disease was mild or very late in occurrence or yields were reduced by Verticillium wilt (9, 11, 12).

High rates of nitrogen with low rates of phosphorus fertilizers have been reported to reduce the incidence of early blight in Maine. Yields were also reduced with this practice, however, making this means of control uneconomical (1). In Colorado, yield increases were more pronounced in response to a fungicide program for control of early blight when potato plants had received nitrogen and phosphorous fertilizers (27).

Many different ground spray programs have been recommended as effective during the last 60 years. Recommended schedules have varied from 3 to 14 days between sprays starting anywhere from when plants are 6 inches tall up through when first lesions are seen, to when plants begin to bloom (5, 9, 13, 15, 16, 18, 19). Harrison (10) used a spore trapping technique and reported that timing of an effective spraying program should be directly related to the detection of secondary sporulation of A. solani.

Recently aircraft have been used to apply fungicides to control early blight because of increased acreage of potatoes and hindrance to ground spraying caused by sprinkler irrigation systems. Aircraft, because of limited tank capacities, are able to apply only 8-10 gals of fungicide solution per acre compared to 100-150 gals by ground application equipment. The reduced gallonage per acre results in fewer droplets per leaf. Analyses have shown that fungicides within droplets do not migrate over the entire leaf surface after wetting by an irrigation, and thus do not provide complete coverage (14). There have been no reports whether fungicide application by aircraft is effective in the control of early blight. The purpose of this three-year study was to monitor the effect on early blight of aircraft-applied fungicides in commercial fields.

METHODS AND MATERIALS

Commercial fields of potatoes under sprinkler irrigation were selected throughout the Columbia Basin (see Table 1). Fungicide-treated strips (300 - 400 ft wide) and nontreated strips (200 ft wide) running the entire length of the fields were located alternately in each field after the last cultivation. White flags (1.5 ft x 3 ft on two 4-ft stakes) were placed at each side and in the middle of the nontreated strips at each end of the fields (50-100 acres per field) so aircraft spray pilots would avoid application. The treatment strips were replicated four times in each field. Five 20-ft samples were selected at random in the middle row of each treatment for harvest. These samples were dug separately for each treatment, but composited to provide production data.

Twenty leaves, just above the lower oldest senescent leaves, were collected at random near the middle of each treatment every two weeks for lesion counts and leaflet isolations. Lesion counts were recorded for each date of collection. Twenty leaflets from each treatment were selected at random from each biweekly leaf collection and cut in half with scissors for isolations. Isolations from half leaflets were by a method reported by Harrison et al. (8), except that a 5-minute soak in 0.00525 sodium hypochlorite rather than mecuric chloride was used to disinfect leaf surfaces. Disinfectant was not washed off the leaf surface before plating. Incubation was at 70°F in the dark.

Resulting fungus colonies of A. solani were identified after 5 days' incubation by the yellow zone of pigmentation around the colony, the purplish sheen of the fungal mat, and the nonsporulation on potato dextrose agar (repeated inoculations to potato foliage confirmed these colonies to be A. solani).

Glass slides coated on one side with Dow Corning High Vacuum Silicone Lubricant (Van Waters and Rogers, Seattle, Wa) were placed in each plot to trap spores of A. solani. Slides were placed coated side down about 1/8 inch above the soil surface and were held by fastening one end through the loop of a jumbo-sized wire paper clip with its bent end stuck into the soil surface. Aerial weather-vane spore traps, similar to those described by Harrison, et al. (10) with slides coated with silicone lubricant and ground level "paper clip" slides were placed in each field plot and in uncropped areas to the west of a few fields to determine the extent of spore dissemination into the fields by prevailing winds. Spores considered on the basis of morphology to be A. solani collected from 20 microscope fields selected at random were counted at X78 magnification under the compound microscope.

Cultural practices, fungicides, rates and times of application for control of early blight for each farm were selected by each cooperator. For most of the fields this was the first crop of potatoes. Therefore, Verticillium wilt would not be expected to interact with the control of early blight (12).

RESULTS

Spore counts from ground slides for the years 1972-1974 from all monitored potato fields showed no consistent differences between plots treated and not treated with fungicides (data not shown). The average counts were 22.7, 22.5, and 47.6 spores per slide for June, July and August, respectively, for all locations for all 3 years.

The Prior Land Company (about 6 mi E of Paterson, Wa) in 1974 averaged 1.5 and 14.8 spores per slide from aerial and ground traps (data not shown). Columbia River Farms (about 1 mi W of Paterson, Wa) averaged 1.0 and 20.2 spores for aerial and ground traps. No spores were trapped in 1974 in uncropped areas westward from these fields.

Alternaria solani isolations from symptomless areas of leaflets for 1972-1974 averaged 0.046, 0.26 and 1.60 isolations per half leaflet for June, July and August, respectively (data not shown). These counts are an average of all plot areas and again no consistent differences were found between areas treated with fungicide and those not treated.

The number of early blight lesions increased from an average of 0.4 lesions in June to 13 lesions in September on leaves collected just above the oldest senescent leaves (Tables 1 and 2). None of the fungicide programs reduced the number of lesions on leaves of plants in the 18 fields studied.

Yields and % U.S. No. 1 tubers were not significantly increased by the early blight spray programs in any of the plot areas evaluated, regardless of the fungicide, number of applications, or time of application.

DISCUSSION

Early blight was not controlled by any spray program where fungicides were applied by aircraft in 8-10 gal of liquid per acre to potatoes grown under sprinkler irrigation (Table 1 and 2). Labels on fungicides used for early blight control on potato usually recommend the application of sufficient gallonage to completely cover the foliage with repeated application at 7-10 day intervals, or sooner if a rain should occur. Eight to ten gal of fungicide solution per acre will not cover both sides of leaflets or penetrate the lower leaves which are most susceptible to infection. Some of the fungicide probably is washed away by the sprinkler irrigations which occur every 1-4 days. Hooker, et al. (14), reported that fungicides in droplets on leaflets were not redistributed to untreated surfaces by rewetting, such as by a sprinkler irrigation. Based on the results of this study we do not recommend aircraft application of fungicides for control of early blight on potatoes under sprinkler irrigation in Washington.

Sprinkler irrigation systems have been proposed as means of applying fungicides to control early blight. Du-ter® recently has been approved for this purpose. We applied 4 applications of Du-ter (8-9 oz actual/a) through a center-pivot irrigation system at a rate of about 4000 gal of solution/a (Easton, G. D., unpublished data). Du-ter, compared to the control, did not control early blight or increase yield or % U.S. No. 1 tubers.

Dissemination of A. solani spores in Washington appear to be different than in Colorado (8, 9). We trapped spores throughout the growing season at the soil surface, but contrary to results reported from Colorado, very few spores were trapped above the foliage until late August and none were trapped coming into the fields with prevailing winds.

Mean temperatures underneath potato plants of the 6 fields listed in Tables 1 and 2 for 1973 were 69.7, 71.2, and 71.1 F for June, July, and August, respectively (Easton, G. D., unpublished data). These temperatures should not limit sporulation of A. solani, since Rotem and Bashi of Israel (25) reported sporulation on potato leaf surfaces at temperatures from 41-86°F with an optimum of 68°F.

Guthrie (6) indicated that early blight increased with the introduction of sprinkler irrigation in Idaho. We have likewise observed an increase of blight under sprinkler compared to row irrigation but rarely an epidemic. However, possibly our frequent sprinkler irrigations (1-4 day intervals), which we have observed to control powdery mildew of potatoes (Erysiphe cicharacearum DC.), are washing aerial spores of A. solani from leaflets and reducing infection and sporulation.

Rarely does an early blight epidemic occur on Russet Burbank potatoes in a sprinkler irrigated field in Washington before August. When an epidemic does occur, plants in such fields invariably show nitrogen deficiency, and the plants appear physiologically old (2, 24). Soltanpour and Harrison showed the importance of plant nutrition in Colorado (27); they could not control early blight when nitrogen was lacking, even with 9 ground sprays of Manzate D.

We were not able to determine from the results of this study whether early blight of potato foliage is an economically important disease in Washington since presently followed practices of applying fungicides by aircraft did not show any control. In general, early blight symptoms are mild until late fall when the host becomes mature and its yielding ability has declined. In intensively cropped potato soils other interacting factors such as Verticillium wilt (12) or late season insect attacks reduce yields and could reduce any benefit of early blight control.

If early blight is an economically important disease problem and ground spraying of fungicides is not feasible, then systemic fungicides may have to be developed for control. Richardson (20) in a greenhouse experiment, reported that aldrin (hexachlorohexahydro-endo, exo-dimethanoaphalene 95% and related compounds 5%), dalpon (2, 2-dichloroproprionic acid), demeton (0, 0 diethyl O and S)-2-(ethylenethio) ethyl phosphorothioate), dieldrin (hexachloroexpoxyoct-ahydro-endo, exo-dimethanonaphthalene 85% and related compounds 15%), IPC (isopropyl carbanilate), MH (1, 2-dihydro-3, 6-pyridazinedione), and NPA (N-1-naphthylphthalamic acid), applied to soil reduced early blight lesions on tomato. The duration of biological activity of these chemicals in the soil was not given.

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Table 1. Farms and their locations, fungicides and their rates, and dates of application for control of early blight.

Test no.a/	Farm and Location	Irrigation System	Year	Fungicides and rates per acreb/		Dates fungicides appliedb/
1.	Balcom and Moe - 5 mi. N. Pasco	wheel	1972	Difolatan 4F®	- 3 pt. actual	8/7, 8/18, 8/29
2.	" " " " Pasco	wheel	1973	Difolatan 4F	- 3 pt. actual	6/4, 7/12, 7/24, 8/14
3.	Charley Cox - 8 mi. E. Plymouth	center	1972	Polyram 80 WP®	- 2 lb. a.i.	6/26, 7/10, 8/12, 8/27
4.	" " " Plymouth	center	1973	Polyram 80 WP	- 2 lb. a.i.	8/14
5.	" " " Plymouth	center	1974	Polyram 80 WP	- 2 lb. a.i.	8/20, 8/27, 9/3
6.	Columbia River - 1 mi. W. Paterson	center	1972	Mansul 80 WP®	- 4 lb. a.i.	6/30, 7/19, 7/28, 8/19
7.	" " " Paterson	center	1973	Polyram 80 WP	- 2 lb. a.i.	6/5, 6/16, 7/18
8.	" " " Paterson	center	1974	Polyram 80 WP	- 2 lb. a.i.	6/18, 6/28
				Dithane M-45 80 WP®	2 lb. a.i.	7/12
9.	Bob Hammond - 7 mi. S.E. Quincy	solid	1972	Difolatan 4F	- 3 pt. actual	8/14, 8/25
10.	" " " Quincy	center	1973	Difolatan 4F	- 3 pt. actual	7/11, 7/25, 8/8, 8/27
11.	K2H Farms - Vicinity of Eureka	center	1972	Mansul 80 WP	- 4 lb. a.i.	6/1, 6/16, 6/30, 7/14
12.	" " " Eureka	center	1973	Du-ter 47.5 WP®	- 10 oz. actual	8/14, 8/25
13.	" " " Eureka	center	1974	Dithane M-45 80 WP	- 2 lb. a.i.	8/16
				Difolatan 4F	- 2 pt. actual	8/30
14.	Prior Land - 10 mi. E. Paterson	center	1974	Difolatan 4F	- 3 pt. actual	8/25
				Difolatan 4F	- 1-1/2 pt. actual	8/31, 9/7
15.	Jack Steffler - Vicinity of George	solid	1972	Manzate 80 WP	- 2 lb. a.i.	6/20, 7/3
				Dithane M-45 80 WP	- 2 lb. a.i.	7/18
16.	" " " George	solid	1973	Dithane M-45 80 WP	- 2 lb. a.i.	7/7, 8/16
17.	" " " George	center	1974	Polyram 80 WP	- 2 lb. a.i.	7/2, 7/24
18.	Universal Farm - 10 mi. E. Pasco	center	1972	Difolatan 4F	- 3 pt. actual	8/7, 8/28

a/ Data for control and production given in Table 2.

b/ Fungicides applied by fixed wing aircraft in 8-10 gal of mixture per acre.

Table 2. Effect of fungicides applied by aircraft to potatoes grown under sprinkler irrigation on control of early blight and potato production.

Test no. [c]	No. early blight lesions per leaf[a]								% U.S. No. 1 tubers[b]		Yield (cwt/a)[b]	
	June		July		August		September					
	treated[d]	Not treated	treated	Not treated	treated	Not treated	treated	Not treated	treated	Not treated	treated	Not treated
1.	0.0	0.1	2.9	2.7	22.1	12.8	---	---	72	73	507	495
2.	0.0	0.0	2.7	5.3	11.7	15.6	---	---	75	75	579	601
3.	0.6	0.6	1.2	2.8	5.5	8.5	---	---	78	77	512	482
4.	---[e]	---	0.0	0.0	1.3	3.2	15.3	13.7	68	69	422	450
5.	0.0	0.0	0.7	0.7	3.0	2.9	2.9	5.8	79	77	392	392
6.	1.0	1.1	0.2	0.6	1.3	5.4	---	---	69	68	412	428
7.	0.2	0.3	0.6	0.8	8.1	9.5	27.1	31.7	76	76	464	480
8.	0.0	0.0	0.3	0.4	1.6	2.0	7.6	8.1	56	58	577	561
9.	3.2	2.3	3.7	1.1	6.6	4.6	---	---	82	79	534	479
10.	0.0	0.0	1.1	1.2	7.2	9.2	7.0	12.5	64	71	505	557
11.	0.1	0.1	0.7	2.6	6.8	1.4	---	---	72	74	595	534
12.	0.1	0.0	0.1	0.6	8.6	7.2	14.5	16.9	73	71	684	705
13.	0.0	0.0	1.8	2.6	7.7	9.9	---	---	45	44	585	562
14.	0.0	0.0	0.1	0.1	14.0	12.5	4.1	3.0	31	41	593	631
15.	1.4	1.4	7.5	3.6	26.5	15.9	---	---	82	83	495	474
16.	0.0	0.0	0.1	0.1	2.3	3.5	---	---	67	75	598	572
17.	0.0	0.0	0.0	0.0	2.5	3.0	12.1	16.5	79	79	423	454
18.	0.5	0.4	1.2	0.6	4.8	4.5	---	---	69	71	406	418
Average	0.4	0.4	1.4	1.4	7.9	7.3	11.3	13.5	69	70	516	515

a/ Average number of lesions from 80 leaves per treatment of biweekly sample with the most lesions for the month.

b/ No significant differences between treated and untreated according to F test at 5% level.

c/ Test location, fungicides, rates of fungicides, and dates of fungicide application given in Table 1.

d/ Foliage fungicides applied as described in Table 1.

e/ Not determined.