Further evaluation of Soil Solarization as a Management Tool for Fusarium Wilt of Lettuce: 2006 Field Trial

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Abstract

Fusarium wilt of lettuce was first recognized in Arizona in 2001. Since this initial discovery, the pathogen, Fusarium oxysporum f.sp. lactucae (Fol), has been recovered from infected lettuce plants from over 40 different fields. This fungus is a soil-borne pathogen that can remain viable in soil for many years. Soil solarization has shown promise in managing Fusarium wilt in other cropping systems as well as in lettuce field trials conducted during 2004 and 2005. In an effort to maximize the solarization effect on subsequent disease development, the following factors were evaluated in a 2006 field trial: 1) solarization of unshaped versus preshaped beds, 2) the effect of soil moisture on solarization efficiency of preshaped beds, and 3) effect of lettuce type on Fusarium wilt incidence after solarization. The entire field was flood irrigated on Jun 21. Plots were solarized during Jul and/or Aug by covering beds with 1-mil thick clear plastic. During the solarization treatment from Jul 3 to Sep 10, the mean soil temperature in preshaped solarized beds at a depth of 2 and 9 inches was 116 and 95°F, respectively, and 102 and 97°F, respectively, in beds not covered with plastic. When solarization was initiated 15 days after soil irrigation, a 20% reduction in Fusarium wilt was recorded for a crisphead lettuce cultivar grown on solarized unshaped beds compared to a 56% reduction in disease when the same crisphead cultivar was grown on preshaped solarized beds. There was no significant difference between a one and two month solarization period in the subsequent number of diseased lettuce plants. Solarization of preshaped beds 15 days after irrigation for one month reduced Fusarium wilt on crisphead lettuce by 56%, whereas the same solarization period initiated seven days after irrigation resulted in a 96% reduction of disease. The same one-month solarization period started one week after soil irrigation reduced the incidence of Fusarium wilt on green leaf (Two Star) and romaine (Green Towers) by 97 and 88%, respectively, compared to plants grown on unsolarized beds. The data show that summer solarization of moist soil can 1) destroy propagules of Fusarium oxysporum f. sp. lactucae in infested fields and 2) be a useful cultural management tool to significantly reduce the incidence of Fusarium wilt in a subsequent crop of lettuce.

Introduction

Fusarium wilt of lettuce was first recognized in Arizona in 2001. Since this initial discovery, the pathogen, *Fusarium oxysporum* f.sp. *lactucae* (*Fol*), has been recovered from infected lettuce plants in over 40 different fields. This fungus is a soil-borne pathogen that can remain viable in soil for many years. Development of disease management strategies for Fusarium wilt will be a formidable challenge. Historically, Fusarium wilt on crops other than lettuce, such as tomatoes and melons, has been successfully managed by developing and planting cultivars resistant to the fungal pathogen. In the long term, development of lettuce cultivars with resistance to (*Fol*) would be highly desirable. As the development of such resistant cultivars may take considerable time, more immediate disease management tools are needed.

Soil solarization has shown promise in managing Fusarium wilt in other cropping systems. A preliminary evaluation of soil solarization on subsequent activity of (*Fol*) was conducted in 2003. A series of 5-gallon plastic buckets was buried in a field at The University of Arizona, Yuma Mesa Agricultural Center, then filled with soil naturally infested with *Fol*. The soil in each bucket was thoroughly irrigated, covered with clear plastic for15, 30, 45 or 60 days, then bioassayed for the presence of *Fusarium oxysporum* f.sp. *lactucae* by sowing and growing lettuce plants within treated soil. The severity of disease symptoms was significantly lower, whereas the fresh weight was significantly higher for lettuce plants grown in soil that was solarized, compared to plants grown in soil not subjected to this treatment. In an initial field trial conducted in 2004, preplant solarization after irrigation of unshaped beds for 40 days resulted in a subsequent 42% reduction in the incidence of symptomatic susceptible crisphead lettuce plants compared to nonsolarized plots. In 2005, further evaluation of solarization in the field revealed that there was no significant difference between a 28- versus 56-day solarization period of preshaped beds on the subsequent number of diseased lettuce plants recorded. In this 2005 study, Fusarium wilt had claimed virtually all lettuce plants of a susceptible crisphead lettuce cultivar growing in nonsolarized soil; however, only 19% of lettuce plants of the same cultivar growing in solarized soil showed disease symptoms. This equates to an 81% reduction in diseased plants in solarized soil compared to nonsolarized soil. The results of this field trial suggest that a 30-day summer solarization treatment of lettuce beds can significantly reduce the inoculum of *Fusarium oxysporum* f. sp. *lactucae* to levels that would allow substantial growth of a susceptible lettuce cultivar. The specific research objective in 2006 was to refine the solarization process to potentially achieve further increases in efficiency of destroying propagules of *Fusarium oxysporum* f. sp. *lactucae* in infested fields.

Materials and Methods

The effect of a preplant soil solarization treatment of planting beds was studied in a five-acre field in Wellton, AZ, previously cropped to lettuce during the 2005-06 season and naturally infested with *Fusarium oxysporum* f.sp. *lactucae*. In an effort to maximize the solarization effect on subsequent disease development, the following factors were evaluated: 1) solarization of unshaped versus preshaped beds, 2) the effect of soil moisture on solarization efficiency of preshaped beds, and 3) effect of lettuce type on Fusarium wilt incidence after solarization. The entire field was flood irrigated on Jun 21. On Jul 3 (12 days after irrigation), unshaped beds with 42 inches between bed centers were listed and covered with 1-mil thick clear plastic. On Jul 6 (15 days after irrigation) beds were preshaped and covered with plastic. In late July, preshaped beds were furrow irrigated, then seven days later covered with plastic. Control beds in all cases were treated similarly to solarized beds except for covering with plastic. The plastic from some plots covered on Jul 6 was removed after approximately one month (Aug 2) and from all plots on Sep 10. Due to rainfall on Sep 12, all preshaped beds as well as unshaped beds were reworked and shaped before planting of test lettuce cultivars, including crisphead (Sahara and 9145), green leaf (Two Star) and romaine (Green Towers), on Sep 16. Soil temperature was recorded at a depth of 2 and 9 inches in beds covered with plastic as well as in beds without plastic. The incidence of Fusarium wilt was recorded at plant maturity on Nov 20, 2006 from 100 ft sections of beds in the trial.

Results and Discussion

During the solarization treatment from Jul 3 to Sep 10, the mean soil temperature at a depth of 2 and 9 inches was 111 and 102°F, respectively for unshaped beds and 116 and 95°F, respectively for preshaped beds. By comparison, in beds not covered with plastic for the same time period, the mean soil temperature at a depth of 2 and 9 inches was 102 and 104°F, respectively for unshaped beds and 102 and 97°F, respectively for preshaped beds.

Solarization of unshaped versus preshaped beds. When solarization was initiated 15 days after soil irrigation, a 20% reduction in Fusarium wilt was recorded for a crisphead lettuce cultivar grown on solarized unshaped beds compared to those grown on nonsolarized unshaped beds. In comparison, a 56% reduction in disease was observed when the same crisphead cultivar was grown on preshaped solarized beds compared to plants grown on prehaped beds that were not solarized. There was no significant difference between solarization for one month or two months.

The effect of soil moisture on solarization efficiency of preshaped beds. When plastic was applied to preshaped beds 15 days after irrigation, a 56% reduction in Fusarium wilt was recorded for the crisphead cultivar compared to the same cultivar grown on nonsolarized beds. On the other hand, when plastic was applied to preshaped beds seven days after irrigation, a 96% reduction in disease compared to nonsolarized beds was realized.

Effect of lettuce type on Fusarium wilt incidence after solarization. After the most effective solarization protocol evaluated this year (plastic placed on preshaped beds seven days after irrigation), the incidence of Fusarium wilt for crisphead ('9145'), green leaf (Two Star), and romaine (Green Towers) lettuce was reduced by 96, 97 and 88%, respectively, compared to plants grown on unsolarized beds.

The results of this and previous field trials suggest that summer solarization of moist soil can 1) destroy propagules of *Fusarium oxysporum* f. sp. *lactucae* in infested fields and 2) be a very useful cultural management tool to significantly reduce the incidence of Fusarium wilt in a subsequent crop of lettuce.

Effect of Fungicides and Lettuce Cultivar on Severity of Botrytis Gray Mold: 2007 Study

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Abstract

Gray mold, caused by the fungus Botrytis cinerea, usually has been considered a minor disease in field-grown lettuce. However, for the past two lettuce production seasons, the incidence of this disease has increased significantly in Southwestern Arizona lettuce fields. Most of the infected fields were planted to romaine lettuce; however, some iceberg lettuce plantings were involved as well. The occurrence of gray mold was most prevalent during February and March. The primary symptoms of the disease include plant wilting accompanied by a fuzzy gray growth at the plant base, which contains masses of airborne spores. Sclerotia may also be present on infected tissue. Infected plants that show these symptoms usually wilt and die. Botrytis cinerea can survive on crop debris, as a pathogen on numerous crops and weed hosts, and as sclerotia in soil. Airborne spores that land on senescent or damaged lettuce stems and leaves germinate and rapidly colonize this tissue. Once established, the pathogen grows into adjacent healthy stems and leaves. A field trial was established to 1) evaluate the effectiveness of some fungicides to reduce the incidence of Botrytis gray mold and 2) compare the susceptibility of some lettuce cultivars to this disease. Botrytis gray mold did not develop in plots of the crisphead cultivar 'Winterhaven'; however, the disease was present in all plots planted with cultivars of romaine lettuce. Among the tested romaine cultivars, Botrytis gray mold incidence was lowest in 'A 35585-1', 'Fresh Heart' and 'Rome 59' in untreated plots as well as in plots treated four times with the fungicides Rovral, Endura, or Switch. On the other hand, disease incidence was highest on the cultivar 'Green Towers' in untreated plots as well as those treated with one of the three tested fungicides. To compare the ability of tested fungicides to control Botrytis gray mold, the disease incidence values for each of the five romaine cultivars treated with each specific fungicide were pooled together and compared to disease levels recorded on untreated plants. Foliar applications of treatments were made Jan 24, Feb 1, Feb 16 and Feb 28, 2007. A 31% reduction in disease was recorded on romaine lettuce plants treated with Switch, whereas a 17% reduction in Botrytis gray mold was observed on plants treated with Endura. Rovral did not significantly reduce Botrytis gray mold in this trial. Additional field trials are planned to verify these initial findings.

Introduction

Gray mold, caused by the fungus *Botrytis cinerea*, usually has been considered a minor disease in field-grown lettuce. However, for the past two lettuce production seasons, the incidence of this disease has increased significantly in Southwestern Arizona lettuce fields. Most of the infected fields were planted to romaine lettuce; however, some iceberg lettuce plantings were involved as well. The occurrence of gray mold was most prevalent during February and March. The primary symptoms of the disease include plant wilting accompanied by a fuzzy gray growth at the plant base, which contains masses of airborne spores. Sclerotia may also be present on infected tissue. Infected plants that show these symptoms usually wilt and die. *Botrytis cinerea* can survive on crop debris, as a pathogen on numerous crops and weed hosts, and as sclerotia in soil. Airborne spores that land on senescent or damaged lettuce stems and leaves germinate and rapidly colonize this tissue. Once established, the pathogen grows into adjacent healthy stems and leaves.

Since gray mold in the past has normally been considered a minor disease on lettuce, specific management tools, including the use of fungicides, have not been tested recently. *Botrytis cinerea*, the cause of gray mold, and *Sclerotinia minor* and *S. sclerotiorum*, the causal agents of lettuce drop, are closely related; therefore, fungicides active against *Sclerotinia* usually are active against *Botrytis* as well. However, it is not known which particular fungicides and timing of applications would be most effective in managing gray mold. Secondly, there may be useful differences among lettuce cultivars with respect to susceptibility to gray mold. The increasing acreage devoted to production of romaine lettuce, use of wide-bed plantings and sprinkler-irrigation are creating environmental conditions extremely favorable for development of Botrytis gray mold. The tremendous amount of spores produced on these infected plants can be easily moved in the air from these sites to nearby healthy lettuce plants, facilitating rapid disease development. The objectives of this study were to 1) evaluate the effectiveness of some fungicides to reduce the incidence of Botrytis gray mold and 2) compare the susceptibility of some lettuce cultivars to this disease.

Materials and Methods

This study was conducted at The Univesity of Arizona, Yuma Valley Agricultural Center. The soil was a silty clay loam (7-56-37 sand-silt-clay, pH 7.2, O.M. 0.7%). The crisphead lettuce cultivar 'Winterhaven' as well as the romaine cultivars 'Green Towers', 'Rubicon', 'Rome 59', 'Fresh Heart' and 'A 35585-1' were seeded Nov 8, 2006 in double rows 12 in. apart on beds with 40 in. between bed centers, then germinated with sprinkler irrigation for 48 hr. Additional furrow irrigations were performed Nov 22, Dec 22, Jan 12, 2007, Feb 2 and 19, and Mar 5. Treatments were replicated five times in a randomized complete block design. Each replicate consisted of 25 ft of bed, which contained two 25 ft rows of lettuce. Plants were thinned at the 3-4 leaf stage to a 12 in. spacing. Treatment beds were separated by single nontreated beds. Treatments were applied with a tractor-mounted boom sprayer that delivered 50 gal/acre at 100 psi to hollow-cone nozzles spaced 12 in. apart. Foliar applications of treatments were made Jan 24, Feb 1, Feb 16 and Feb 28, 2007. Maximum and minimum ranges (°F) of air temperature were as follows: Dec, 2006, 58-77, 29-50; Jan, 2007, 49-77, 22-50; Feb, 63-83, 36-53; Mar 1 to 15, 66-94, 33-56. Maximum and minimum ranges (%) for relative humidity were as follows: Dec 2006, 20-94, 4-38; Jan 2007, 36-96, 8-34; Feb, 58-90, 7-31; Mar 1 to 15, 44-85, 5-12. No rainfall occurred during this trial. The incidence of disease was determined at plant maturity (Mar 14) by recording the number of dead and dying plants in each plot that had symptoms of Botrytis gray mold. As a point of reference, the original stand of lettuce was thinned to 50 plants per plot.

Results and Discussion

Botrytis gray mold did not develop in plots of the crisphead cultivar 'Winterhaven'; however, the disease was present in all plots planted with cultivars of romaine lettuce. Among the tested romaine cultivars, Botrytis gray mold incidence was lowest in 'A 35585-1', 'Fresh Heart' and 'Rome 59', in untreated plots as well as in plots treated four times with the fungicides Rovral, Endura, or Switch. On the other hand, disease incidence was highest on the cultivar 'Green Towers' in untreated plots as well as those treated with one of the three fungicides. To compare the ability of tested fungicides to control Botrytis gray mold, the disease incidence values for each of the five romaine cultivars treated with each specific fungicide were pooled together and compared to disease levels recorded on untreated plants. A 31% reduction in disease was recorded on romaine lettuce plants treated with Switch, whereas a 17% reduction in Botrytis gray mold was observed on plants treated with Endura. Rovral did not significantly reduce Botrytis gray mold in this trial. Additional field trials are planned to verify these initial findings.

2006-2007 Botrytis Gray Mold Fungicide and Lettuce Cultivar Evaluation Trial

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Lettuce cultivar	Mean number of plants per 25 ft plot with Botrytis gray mold [1]			
	Untreated plants	**Rovral 4F @ 1.0 qt of product/acre**	**Endura 70WG @ 0.69 lb product/acre**	**Switch 62.5WG @ 0.875 lb product/acre**
Winterhaven	0 [2]	0	0	0
A 35585-1	5.8 b [3]	5.2 b	4.6 c	3.8 c
Fresh Heart	6.2 b	6.0 b	5.0 bc	4.2 bc
Rome 59	6.8 b	6.2 b	5.4 bc	4.8 bc
Rubicon	7.2 ab	6.6 b	6.4 ab	5.2 ab
Green Towers	8.8 a	9.2 a	7.8 a	6.2 a
All cultivars combined	**7.0 A** [4]	**6.6 A**	**5.8 B**	**4.8 C**

1 Treatment dates: 1 = Jan 24; 2 = Feb 1; 3 = Feb 16; 4 = Feb 28, 2007. Disease incidence data collected Mar 14.

2 No Botrytis gray mold developed on the crisphead cultivar ‘Winterhaven’ in this trial. This cultivar was not included in the statistical analysis of data.

3 Values in each column followed by a different lower case letter are significantly different (LSD test, *P* = 0.05).

4 Values in this row followed by a different upper case letter are significantly different (LSD test, *P* = 0.05).