Optimizing soil solarization for management of Fusarium wilt and evaluation of control strategies for Botrytis gray mold

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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 from 2004 to 2006. Gray mold, caused by the fungus *Botrytis cinerea*, usually has been considered a minor disease in field-grown lettuce; however, the incidence of this disease has increased in Southwestern Arizona lettuce fields in recent years. Field trials during the 2006-07 lettuce growing season demonstrated differential romaine cultivar susceptibility to gray mold as well as a 31% reduction in disease on plants treated with the fungicide Switch. Field trials were conducted during 2007-08 to further evaluate soil solarization as a management tool for Fusarium wilt and to continue studies on the effect of lettuce cultivars and fungicides on development of gray mold. In the Fusarium wilt trial, soil solarization reduced disease incidence by 62% compared to nonsolarized beds. This level of disease reduction was less than the 96% reduction of Fusarium wilt achieved during the 2006 trial. One contributing factor in this decrease in disease control was that the soil temperature in solarized beds at a depth of 2 inches was lower in 2007 compared to 2006. There is no data to report concerning Botrytis gray mold on lettuce as no disease developed in the plots. Reasons for the lack of Botrytis gray mold development are not clear. The general weather parameters during this growing season were not significantly different from those in the preceding season, when gray mold did develop in our trial.

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. 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. Finally, in a 2006 field trial, when plastic was applied to preshaped beds 15 days after irrigation, a 56% reduction in Fusarium wilt was recorded for a 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. The solarization treatment in 2006 ran from Jul 3 to Sep 10. The specific objective in 2007 was to repeat the performance of the solarization treatment recorded in 2006.

Gray mold, caused by the fungus *Botrytis cinerea*, usually has been considered a minor disease in field-grown lettuce. However, the incidence of this disease has increased in Southwestern Arizona lettuce fields in recent years. 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. Field trials were conducted during the 2006-07 lettuce production season to evaluate the effect of lettuce cultivars and fungicides on the severity of Botrytis gray mold. Among 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. 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. The objective of this study was to verify the initial findings from the trials conducted in the 2006-07 season.

Materials and Methods

Fusarium wilt. The effect of a preplant soil solarization treatment of planting beds was studied in a five-acre field in Wellton, AZ, naturally infested with *Fusarium oxysporum* f.sp. *lactucae*. Beds were preformed and shaped, then irrigated by sprinkler irrigation to thoroughly wet the soil. Four days after the sprinkler irrigation was terminated, 600-ft-long beds were covered with a 1-mil thick sheet of plastic film that is routinely used for soil solarization. Similar length beds not covered with plastic served as controls. Treatments (solarized or nonsolarized) were replicated four times in a randomized complete block design. The plastic was maintained on the solarized beds from Aug 14 to Sep 16. Solarized and nonsolarized beds then were seeded with the lettuce cultivar 'Raider' on Sep 19 and sprinkler-irrigation was initiated Sep 20 to germinate the seed. 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 Dec 13, 2007 from 100 ft sections of beds for each plot within the trial.

Gray mold. Building upon the preliminary results from last year, a field trial was established to evaluate fungicides, application timing, and different lettuce cultivars with the goal of finding useful management tools for this disease. This study was conducted at the 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 romaine cultivars Rubicon, Rome 59, Fresh Heart and A-35585-1 were

seeded, then irrigated to germinate seed on Nov 8, 2007 on double rows 12 in. apart on beds with 40 in. between bed centers. Cultivar, fungicide treatment, and timing plots 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 Dec 12. Treatment beds were separated by single nontreated beds. Tested fungicides, including Endura, Rovral, Switch, and Botran, were applied with a tractor-mounted boom sprayer that delivered 50 gal/acre at 100 psi to flat-fan nozzles spaced 12 in. apart. Foliar applications of these fungicides were made either in mid- and late-January or mid- and late-February, 2008. Maximum and minimum ranges (°F) of air temperature were as follows: Dec, 2007, 56-74, 29-51; Jan, 2008, 56-73, 32-51; Feb, 61-84, 32-53; Mar 1 to 14, 70-86, 39-54. Maximum and minimum ranges (%) for relative humidity were as follows: Dec 2007, 37-97, 8-47; Jan 2008, 17-97, 9-80; Feb, 55-88, 10-42; Mar 1 to 15, 40-81, 6-17. Measurable rainfall occurred in Dec (0.01 in.) and in Jan (0.33 in.). Furrow irrigations supplied all water for crop growth. The incidence of disease was determined at plant maturity (Mar 10 to 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

Fusarium wilt. During the solarization treatment from Aug 14 to Sep 16, the mean (and range) of soil temperatures at a depth of 2 and 9 inches was 109°F (90 to 132°F) and 104°F (96 to 111°F) , respectively for solarized beds and 103°F (88 to 123°F) and 100°F (95 to 106°F) , respectively for nonsolarized beds. At crop maturity, a mean number of 154 lettuce plants showed symptoms of Fusarium wilt per 100-ft length of nonsolarized bed. In contrast, 58 plants exhibited disease symptoms in the same length of bed in solarized plots. Compared to nonsolarized beds, soil solarization reduced disease incidence by 62% in this trial. This is a respectable level of disease reduction, but much less than the 96% reduction of Fusarium wilt achieved during the 2006 trial. One major difference between the trials in 2006 and 2007 was that recorded soil temperatures in solarized plots at a depth of 2 inches in the 2006 and 2007 trials was 116 and 109°F, respectively. The lower mean soil temperatures in 2007 could have been the result of the later initiation of solarization in 2007 (Aug 14) compared to 2006 (late July) or due to general differences in temperature between the two years. Lower soil temperatures during solarization would reduce the effectiveness of solarization as a means of killing inoculum of *Fol* in the soil. The results of this and previous field trials demonstrate 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.

Gray mold. There were no data to report concerning Botrytis gray mold on lettuce as no disease developed in the plots. Coincidentally, growers did not report much gray mold in commercial fields as well. Reasons for the lack of Botrytis gray mold development are not clear. The general weather parameters during this growing season were not significantly different from those in the preceding season, when the disease did develop in our trial.