

**Project title:** The effects of planting date and varietal susceptibility on severity of Fusarium wilt in lettuce

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## **Abstract**

Fusarium wilt of lettuce, caused by *Fusarium oxysporum* f. sp. *lactucae*, is a serious disease affecting lettuce production in most major growing districts in California and Arizona. The disease is most problematic in warmer areas but affected fields have also been identified near the coast, most of them in the vicinity of King City. Our previous work has shown that although iceberg cultivars differ in susceptibility to Fusarium wilt, all of them will succumb if disease pressure is high enough. On the other hand, some romaine and leaf cultivars appear to be completely resistant, even under the most severe conditions. Because our last comprehensive assessment of cultivars was undertaken ten years ago, we initiated a follow-up survey to provide information on the susceptibility of currently grown cultivars. Of the fifty cultivars that were tested, eight romaine types were rated as resistant. One crisphead cultivar was intermediate (rating = 1.5) and the remaining 32 crisphead types were susceptible (rating > 2.0). Severity of disease on susceptible cultivars will be determined in part by the temperatures that prevail during the growing season. Consequently, it may be possible to grow susceptible cultivars during the cooler part of the year. To test this possibility, we established a trial in a grower field, in which a mix of cultivars was planted on three different dates. Unfortunately, disease developed only to a limited extent, even in susceptible cultivars. This was due to low inoculum levels, which were found to be less than 35 colony-forming units per gram of soil. For susceptible and moderately resistant cultivars, the extent to which disease develops will be strongly influenced by the amount of inoculum to which they are exposed. Consequently, minimizing the build-up of inoculum in soil is an essential component of disease management. For this reason we have initiated studies to determine if drying of crop residue on the soil surface prior to incorporation will influence pathogen survival. The results showed that six months after incorporation inoculum levels were 38% lower, on average, in plots in which residue was allowed to dry on the soil surface prior to incorporation.

## **Objectives**

1. Screen a representative selection of crisphead and romaine cultivars for susceptibility to Fusarium wilt
2. Establish field trials in Fresno County to assess the effect of planting date and ambient temperatures on severity of Fusarium wilt
3. Determine the effect of drying crop residue prior to incorporation on survival of the Fusarium wilt pathogen

## **Procedures**

### Objective 1

Lettuce cultivars were tested for susceptibility to Fusarium wilt using a root-dip inoculation. Seedlings with one true leaf were up-rooted, the roots washed in water and dipped in a spore suspension of the pathogen. Inoculated plants were maintained in a greenhouse for 3-4 weeks, after which they were rated on a 1-4 scale: 1 = no symptoms, 2 = stunted and/or mild foliar symptoms, 3 = severely stunted and 4 = dead. Cultivars tested were representative of those that are currently most widely grown, with an emphasis on crisphead types, as these are most severely affected by Fusarium wilt. Seeds of each cultivar were kindly provided by Gowan seed. Known resistant and susceptible cultivars were included as controls.

### Objective 2

Twenty-eight to 35 cultivars were planted on one of three dates in a commercial field in the Five Points area of Fresno County (Table 2). Entries were selected based on performance in past trials and suggestions from industry representatives. Each planting was established as a randomized complete block with four replications. Plots were single 40 inch beds with two seed lines, 12 to 15 feet in length, for a total trial area of four beds x 2600 feet. Plants were rated for symptoms of Fusarium wilt at eight, ten and 12 weeks after planting for the first, second and third trials, respectively. To provide an indication of disease pressure, soil was assayed to determine the abundance of inoculum of the Fusarium wilt pathogen. Within each trial (= planting date) a composite of multiple soil cores was taken from each replication. Inoculum density was estimated by suspending soil in water and spreading dilutions of this suspension on the surface of plates containing a Fusarium-selective medium. Colonies corresponding to the Fusarium wilt pathogen were enumerated seven days later.

### Objective 3

Infected lettuce plants were obtained from an experimental field on the Davis campus that is infested with the Fusarium wilt pathogen. Plants harvested from this field were transferred to microplots (2' x 2') and either incorporated immediately or spread over the soil surface and allowed to dry for eight days prior to incorporation. Thirteen days after incorporation of the dried residue, soil in all plots was mixed using a hand-held cultivator. At one, two, three and six

months after incorporation of the dried residue, soil cores were removed from each plot and assayed to determine the state of decomposition of the residue and the density of inoculum. Inoculum density was estimated using the procedure described above under objective 2. The experiment, initiated in fall of 2013, consisted of two treatments (residue dried on the soil surface or not) with five replications of each treatment.

## **Results and Discussion**

Fifty cultivars were tested using a root-dip inoculation procedure. Based on this test, eight cultivars were rated as resistant (disease severity score of < 1.5 on a 1-4 scale, with 1 = healthy and 4 = dead). All those in the resistant category were romaine types (Table 1). One crisphead cultivar was intermediate (rating = 1.5) and the remaining 32 crisphead types were susceptible (rating > 2.0). Eight of the 16 romaine cultivars tested were resistant to Fusarium wilt, six were intermediate (rating = 1.5 – 1.9) and two were susceptible (Table 1). All these tests are being repeated and results will be included in next year's report.

Only very mild symptoms of Fusarium wilt were observed in the field trials conducted in Fresno County. In the August 24 planting, most cultivars remained free of disease. Symptoms of Fusarium wilt were detected in Bubba, Lighthouse, Darkland, Sun Quest, Raider, Diamondback and Mighty Joe. The highest incidence was in Mighty Joe (3.2%) and the lowest was in Bubba, at about 1%. The same cultivars also had a low incidence of disease in the second planting, with no disease in any of the other cultivars. Similarly, in the third planting, most cultivars remained healthy throughout the season, with less than 1% of plants showing symptoms in the following cultivars: Costa Rica #4 (14421), Sahara, Del Sol, Dover, Expt. 1, Banchu Red Fire and King Louie. Because of the very limited development of Fusarium wilt, it was not possible to make meaningful comparisons between cultivars.

The low incidence of disease can be attributed to low levels of inoculum in the soil at the site where the experiment was conducted. The Fusarium wilt pathogen was not detectable in any of the 12 samples that were assayed. This test had a detection threshold of 35 colony forming units per gram of soil, so the pathogen may have been present below this level, which would be consistent with the occurrence of some diseased plants in each trial. Previous work indicates that disease risk tends to be low at inoculum densities below 50 colony forming units per gram of soil. The trial was located in this field because the test site used in 2012 was unavailable due to lack of water. In 2013, site selection was based on field history and grower cooperation. In the event that a more favorable site is not available in Fresno County in 2014, the trial will be conducted in an infested field at UC Davis.

Table 1. Cultivars tested for susceptibility to Fusarium wilt using a root-dip inoculation procedure.

Cultivar	Type	Rating
7101 A	Head	1.85
Black Belt	Head	2.15
Bubba	Head	2.09
Cheetah	Head	1.70
Corona	Head	2.20
El Guapo	Head	1.65
EXP 1221	Head	1.85
Gabilan	Head	1.60
Hallmark W	Head	1.70
Keeper	Head	2.00
Laguna Fresca	Head	2.35
Navajo	Head	1.55
PRO 1543	Head	2.00
PRO 1544	Head	1.80
PRO 1546	Head	2.15
PRO 1551	Head	2.15
PRO 1555	Head	2.90
PRO 1565	Head	2.70
PRO 1569	Head	2.00
PRO 1583	Head	1.60
PRO 1587	Head	2.45
PRO 1617	Head	2.10
PRO 1618	Head	1.60
PRO 1619	Head	1.80
PRO 1844	Head	1.55
Quest	Head	1.80
Raider	Head	1.55
Reliant	Head	1.00
Sniper	Head	1.80
Sureshot	Head	1.60
Tellmark	Head	1.70
Vandenburg	Head	1.65
Venus	Head	2.25
Lolla Rossa	Leaf	1.80
Brave Heart	Romaine	1.77
Caesar	Romaine	1.00
Fresh/Heart	Romaine	1.05
Golden Forest	Romaine	1.75
Green Thunder	Romaine	1.25
Green Towers	Romaine	2.10

Table 1. Continued

Heavy Heart	Romaine	1.35
Inferno	Romaine	1.80
King Henry	Romaine	1.70
PRO 1466	Romaine	1.10
PRO 1479	Romaine	1.30
Regency 2.0	Romaine	2.45
Rio Bravo	Romaine	1.93
Salvius	Romaine	1.10
Sun Valley	Romaine	1.30
True Heart	Romaine	1.50

Prior to initiation of the residue treatment experiment, soil in all microplots was assayed and shown to be free of the pathogen. One month after incorporation of dried residue, inoculum densities were  $1295 \pm 702$  and  $857 \pm 174$  colony forming units per gram of soil in the immediate incorporation and dried residue plots, respectively. Thus, inoculum levels were 34% lower, on average, in plots in which residue was allowed to dry on the soil surface prior to incorporation. This differential remained but was of lower magnitude (15%) when soil was assayed at two months after incorporation. One month later inoculum levels were higher in both treatments, with little difference between them (Figure 1). This increase is presumably associated with decomposition of the residue, which results in more fungal propagules (spores and hyphal fragments) because they are associated with smaller fragments of infected tissue. At six months after incorporation, inoculum densities decreased in both treatments and were 38% lower in plots in which residue was dried prior to incorporation (Figure 1). However, based on a t-test, the difference between the two treatments at this last assay interval was not significant ( $P = 0.149$ ).

In summary, results from the first year of our project show all tested crisphead cultivars to be susceptible to Fusarium wilt, and a subset of romaine cultivars to be resistant. This is consistent with our previous findings and suggests little change in the level of resistance in contemporary cultivars relative to those that were commonly grown ten years ago. Preliminary results from residue treatment experiments indicate that drying residue on the soil surface may enhance the rate at which inoculum levels decline after incorporation.

Table 2. Cultivars planted in Fresno County on one of three dates in fall of 2013

Planting dates		
August 24	August 30	September 5
Banchu Red Fire	Bubba	Banchu Red Fire
Bubba	Crusader	Bubba
Conquistador 14731	Darkland	Conquistador 14731
Costa Rica #4	<u>Del Sol</u>	Costa Rica #4 (14421)
Darkland	Diamondback	Crusader
Del Sol	Dover	Darkland
Diamondback	El Guapo	Del Sol
Dover	Fresh Heart	Diamondback
El Guapo	Green Forest	Dover
Expt. 1	Green Towers	Fresh Heart
Green Towers	Greenbelt	Green Forest
Heatmaster	Heatmaster	Green Towers
Javolina	Javolina	Greenbelt
Keeper	Keeper	Heatmaster
King Louie	Lighthouse	King Louie
Lighthouse	Mighty Joe	Lighthouse
Patriot	Raider	Mighty Joe
PYB7101A	Reliant	Patriot
Raider	Sahara	Raider
Reliant	Sidewinder	River Green 14057
River Green 14057	Sniper	Sahara
Sahara	Solid King	Salinas 14142
Salinas 14142	Sun Belt	Sawa Up 14732
Sawa Up 14732	Sun Devil	Sidewinder
Sidewinder	Sun Quest	Sniper
Sniper	Sun Valley	Solid King
Solid King	Sureshot	Sun Belt
Sun Belt		Sun Devil
Sun Devil		Sun Quest
Sun Quest		Sun Valley
Sun Valley		Sureshot
Sureshot		Vanguard
Vanguard		Vanguard 75 14060
Vanguard 75 14060		

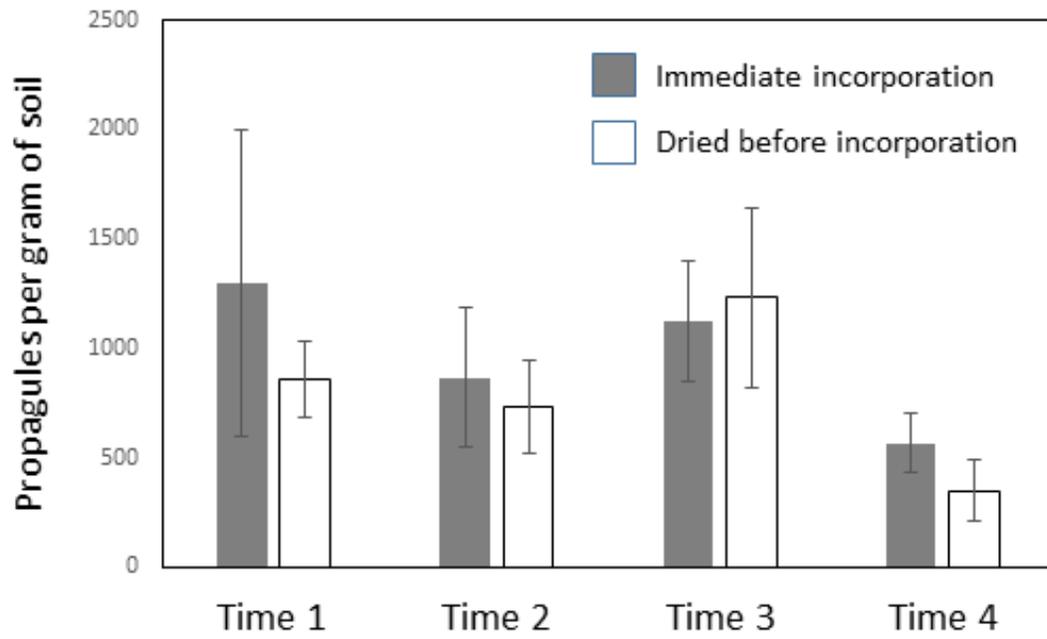


Figure 1. The height of each bar corresponds to the number of colony forming units of *Fusarium oxysporum* f. sp. *lactucae* per gram of soil. Error bars correspond to the standard error of the mean.