

Crop Rotation with Broccoli for Management of Verticillium Wilt

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Verticillium wilt is the most important soilborne pathogen of strawberries because of the premature plant death it causes. Estimates of crop losses vary but range between 30-50% in the absence of soil fumigation. Currently available commercial strawberry cultivars are all highly susceptible to Verticillium wilt. The disease has been managed effectively by pre-plant soil fumigation with methyl bromide and chloropicrin. The imminent loss of methyl bromide, however, leaves few alternatives for effective management of Verticillium wilt and other soilborne diseases in strawberries. The disease is caused by the fungus, Verticillium dahliae, which is widely distributed in the agricultural soils in California affecting such diverse crops as artichokes, cotton, pepper, pistachio, potato, strawberry, tomato, watermelon, and a number of crucifer crops. The fungus produces characteristic black resting bodies called microsclerotia that survive in the soil for at least 10 years. As few as 2 microsclerotia per gram of soil can result in 100% disease incidence.

Continuous cultivation of strawberries increases the populations of pathogenic microorganisms including the microsclerotia of V. dahliae in the absence of soil fumigation. In contrast, crop rotations generally reduce the populations of pathogens because pathogens of one crop are unlikely to infect and multiply on an unrelated crop. Because of the wide host range of V. dahliae, crop rotations generally have been ineffective for the

management of Verticillium wilt. However, all of this changed with our discovery of broccoli as an effective rotation crop for reducing the incidence of Verticillium wilt in cauliflower (Koike and Subbarao, 2000, Broccoli residues can control Verticillium wilt of Cauliflower, California Agriculture 54:30-33). We had previously demonstrated in growers' fields that incorporation of broccoli residue in amounts representing what is left over after commercial harvest reduced the number of microsclerotia by more than 60% within one season and repeating the process the second year nearly eliminated the pathogen. This significantly reduced the incidence of

## **Report Highlights**

- Rotation with broccoli or Brussels sprouts can reduce severity of Verticillium wilt
- It is important to allow the crop to grow to maturity, flail mow plants to fine pieces, and allow residue to dry on the soil surface for several days prior to soil incorporation.

Verticillium wilt on the subsequent cauliflower crops and the numbers of microsclerotia formed on the infected cauliflower roots. This was in contrast to a temporary reduction in the number of microsclerotia observed with the chemical fumigants; at the end of the cropping season the number of microsclerotia were back to the levels observed prior to fumigation. Additional studies determined that during production of the broccoli crop there was no reduction in the numbers of microsclerotia, but within a month after the residue incorporation, the microsclerotia declined and this reduction continued during the subsequent cauliflower crop. These effects were observed regardless of the irrigation methods and regimes employed. In a related study, we also demonstrated that fresh broccoli to be significantly more effective than dry broccoli, and to maximize broccoli-mediated pathogen attrition in soil, the residue should be incorporated when the soil temperature is at least 20 C. Rotations with broccoli also significantly reduced the soilborne sclerotia of Sclerotinia minor and the incidence of lettuce drop.

The mechanisms by which broccoli residue acts on soilborne pathogens could be chemical, biological, or both. During decomposition of crucifer residues, enzymatic degradation of glucosinolates (group of chemicals characteristic in crucifer crops) produces sulfides, isothiocyanates, thiocyanates, and nitriles. These chemicals have been attributed to reduce propagule numbers of a range of pathogens. Because these chemicals are volatile, their effects on soilborne pathogens, particularly on the microsclerotia of V. dahliae, can at best be considered transient. Recent work by others and us has shown that the primary mechanism of broccoli-mediated suppression of V. dahliae microsclerotia may be the enhancement of antagonistic soil microorganisms.

## Materials and Methods

Based on the success of rotations of broccoli crop with cauliflower and lettuce for the management of Verticillium wilt and lettuce drop, respectively, we began testing the effect of rotations of broccoli, Brussels sprouts, and lettuce with strawberries for the management of Verticillium wilt and other soilborne diseases. Experimental plots were set up at the Monterey Bay Academy in Watsonville in soil naturally infested with V. dahliae microsclerotia. Treatments were replicated 4 times with 2 beds per replicate and each treatment block was 25 ft long. Strawberry was grown in the plots in the 1996 season, followed by vegetable rotation crops during the 1997 season. After harvest, all vegetable crop residues were flail shredded, air dried on the surface for a minimum of two days and incorporated into the soil using a rototiller. Four weeks after incorporation, the beds in all plots were reworked for the next crop cycle. Strawberry (cultivar Selva) was grown in all treatment

## The Pink Sheet

plots during the 1998 season to assess the effects of different rotation treatments and the experiments were repeated during the 1999-2000 season. Plots fumigated with methyl bromide+chloropicrin (57:43 at 325 lbs/A) were used for comparison with rotation treatments. All strawberry plots were managed with standard commercial practices with harvest of culls and marketable

yields collected on a weekly basis. Plant diameters and assessment of Verticillium wilt incidence and severity were collected at periodic intervals. The disease severity estimate was done on the scale of 0 to 8, where 0 =healthy plant, 2 = moderately stunted, 3 = moderately stunted, slight rosette of dead leaves, 4 = moderately stunted, moderate rosette, 5 = significantly stunted, slight rosette, 6 = significantly stunted, moderate rosette, 7 =significantly stunted, significant rosette, 8 = dead plant. Soil samples to determine the densities of *V. dahliae* propagules and total *Pythium* population were collected at beginning and at the end of the rotational crop, and every month after the start of the strawberry crop.

## Results

Inoculum levels of *V. dahliae* were influenced by the crop that was grown in the soil. Broccoli rotations reduced the inoculum significantly and levels remained consistently low throughout the sampling period. Brussels sprouts also reduced inoculum, but to a lesser degree than broccoli whereas lettuce had a slight stimulatory or neutral effect on pathogen inoculum levels. Total populations of *Pythium* spp. were not influenced by crop rotation strategy. However, since there are differences in aggressiveness of various *Pythium* species on strawberry, additional studies are in progress to evaluate the influence of crop rotation on specific species.



The rotation treatments had a significant effect on the Verticillium wilt disease severity rating during all of the observation points. Strawberry plants grown in lettuce rotation treatment plots had the highest disease severity rating in both seasons. Strawberry plants in broccoli rotation treatment showed a consistently lower disease severity than in the rest of the crop rotation treatments during the season. Strawberry plant canopy diameter also was higher in the broccoli rotation treatment compared with lettuce treatment. Methyl bromide and chloropicrin fumigation produced the highest marketable strawberry yields. While there was a 23% reduction in yield for the broccoli rotation plots in 1998, this was significantly better than the 39% yield reduction encountered with the

lettuce rotation plots. Similar experimentation is in progress at the USDA research plots in Salinas where V. dahliae is not a production problem to evaluate the influence of crop rotation on root rotting pathogens. The studies at the MBA site have recently been expanded to include larger test plots as well as the addition of plots in an organic production system.