BROCCOLI RESIDUE FOR VERTICILLIUM WILT CONTROL: A POTENTIAL ALTERNATIVE TO CHEMICAL FUMIGANTS

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Verticillium wilt caused by the fungus *Verticillium dahliae* is a serious production constraint on many economically important crops. The pathogen survives in soils as microsclerotia for many years. The disease is generally managed with a combination of chemical and cultural methods. In most crops, genetic resistance is not available for Verticillium wilt. Solarization of soil is effective but is restricted to warm, sunny climates. Crop rotation with nonhosts is usually practiced but formation of microsclerotia on some nonhosts makes the choice of crops for rotation difficult. While fumigation with a mixture of methyl bromide and chloropicrin is highly effective, the proposed withdrawal of methyl bromide leaves few chemical alternatives.

The use of certain crop residues to manage Verticillium wilt has shown promise for certain cropping systems. In this context, our determination of broccoli as a nonhost seems significant and offers new avenues to manage this disease. Although broccoli and cauliflower are related, Verticillium wilt has not been observed on broccoli even when planted in soil heavily infested with microsclerotia. Repeated attempts to isolate the pathogen from apparently symptomatic broccoli plants have also been unsuccessful, and *V. dahliae* microsclerotia on broccoli roots have not been observed.

We hypothesized that rotations with broccoli may reduce *V. dahliae* propagules in soil and the corresponding Verticillium wilt incidence. Rotation effects of broccoli on *V. dahliae* propagules may occur in two stages: i) propagule dynamics during the broccoli crop; and ii) propagule dynamics after the residue is incorporated into the soil. In the last two years, we have demonstrated the latter part of the broccoli rotation, i.e., demonstrated the effectiveness of broccoli residues for *V. dahliae* propagule reduction, and the corresponding decline in Verticillium wilt incidence in a highly infested grower's field. The hypothesis was tested on cauliflower - Verticillium wilt host-pathosystem. Results from these experiments demonstrated that broccoli residue significantly reduced the number of *V. dahliae* microsclerotia compared with unamended plots. Further, the reduction was generally greater than in plots treated with conventional fumigation treatments. An important finding was that the decline in the number of microsclerotia in broccoli treated plots occurred throughout the season. Whereas the fumigation treatments were followed by an initial decline in microsclerotia, with increased numbers towards the end of the season. These results suggest that compared with the short-term propagule reduction in fumigation treatments, broccoli residue can provide a long-term reduction in pathogen propagules, perhaps by reducing existing soilborne microsclerotia and/or by preventing their formation on susceptible crops.

Further experiments to determine the agricultural practices under which the effects of broccoli are optimized and to understand the mechanisms of broccoli-mediated propagule reduction were

conducted in a field fumigated with a mixture of methyl bromide and chloropicrin. The experimental design was a 3 x 2 x 3 factorial combination of treatments arranged in a split-split-plot design with three replications. Treatments consisted of three main plots, two sub-plots, and three sub-sub-plots. The main plots included broccoli rotation in *V. dahliae*-infested plots, no broccoli rotation in infested plots (fallowed during broccoli season), and noninfested control, the sub-plots were two irrigation methods (furrow and subsurface-drip), and sub-sub-plots were the three irrigation regimes (deficit, moderate and excessive). Each treatment (sub-sub-plot) was 6 beds wide (1-m between bed centers) and 9 m long. The sub-plots were separated by 2 m of bare soil and the main plots were separated by 6 m of bare soil to reduce plot interactions. The middle four beds of each sub-sub-plot in two main plots (broccoli rotation in *V. dahliae*-infested plots and no broccoli in infested plots) were uniformly infested with soil containing *V. dahliae* microsclerotia at the beginning of the experiment.

Both disease incidence and severity were significantly ($p \leq 0.05$) lower in the treatments with broccoli residue compared with treatments without broccoli and averaged twice as great in nonbroccoli treatments as in broccoli treatments. Both the final incidence and severity of Verticillium wilt were not significantly ($p \leq 0.05$) different between furrow and subsurface-drip irrigation treatments, but were significantly ($p \leq 0.05$) lower in the deficit compared to moderate and excessive irrigation regimes. Differences between moderate and excessive treatments were not significantly ($p \leq 0.05$) different. The reduction in the number of microsclerotia from initial to final sampling period was about 70% in treatments involving broccoli compared with stable numbers in treatments without broccoli. Formation of microsclerotia on the roots of infected cauliflower plants 8 wk after harvest was also significantly ($p \leq 0.05$) higher in treatments without broccoli.

Populations of actinomycetes, bacteria, and fungi were monitored during broccoli and cauliflower growing seasons at three-wk intervals and during the post-broccoli incorporation period at five-day intervals. Populations of actinomycetes and bacteria increased significantly ($p \leq 0.05$) during the broccoli growing season in plots with the broccoli crop compared with fallow plots. Populations of fungi remained stable. After broccoli incorporation, actinomycete, bacterial, and fungal populations increased significantly ($p \leq 0.05$) in soils with broccoli residue over soils without the residue. Cauliflower was transplanted into all plots about six weeks after broccoli incorporation, and populations of actinomycete, bacteria, and fungi were significantly ($p \leq 0.05$) higher throughout the season in soils that previously received broccoli residue than in soils without broccoli. Specific roles of these groups of microorganisms in *V. dahliae* propagule reduction are currently being investigated as also the role of cauliflower residue on the dynamics of these microorganisms.