# Management of Verticillium Wilt Using Green Manure Biofumigants

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## Introduction

Verticillium wilt caused by the fungus *Verticillium dahliae* is the most important disease of commercial mint production. Rotation to non-hosts is difficult since inoculum of *V. dahliae* can survive in field soils for ten years or more and the pathogen has a wide host range. Green manure crops with biofumigant properties, specifically those which produce glucosinolate-derived compounds such as allyl isothiocyanate, can suppress the growth of a broad range of weeds, bacteria, nematodes, and fungi, including *Verticillium dahliae*. Fast-growing, short-term cover crops could be beneficial in central Oregon since a window of opportunity exists for a green manure cover crop during a 2 to 3-month period in late summer and early fall. The objective of this project was to evaluate potential late summer-planted green manure crops for biomass production potential, their effects on *V. dahliae* inoculum levels, and their impact on Verticillium wilt symptoms of mint in a microplot study under central Oregon growing conditions.

## Materials and Methods

A microplot experiment was established at COARC to determine if selected green manure crops can produce sufficient biomass if planted in late summer in central Oregon. Round (24" diameter x 18" tall), bottomless nursery pots were placed in the ground so that the tops were approximately 2" above soil level. Each microplot was infested with a VCG 2B isolate of *V. dahliae* obtained from mint (approximately 3 CFU/$cm^3$ soil). Green manure crops were broadcast planted at recommended rates (Table 2) on August 11, 2015 and grown using overhead irrigation. Other treatments consisted of allyl isothiocyanate at 10- and 40 gal/acre, a non-treated/non-infested control, and a non-treated/infested control. A non-infested allyl isothiocyanate treatment (40 gal/acre) was also included to determine if allyl isothiocyanate can cause phytotoxicity in peppermint. Green manure biomass was measured on October 8, 2015, after which green manures were chopped and incorporated by hand into each microplot. Microplots were planted with greenhouse-grown rhizomes of Black Mitcham peppermint on November 5, 2015.

Soils from each microplot were sampled in March 2016 and assayed for *V. dahliae* using NP-10 semi-selective medium. Verticillium wilt incidence (the number of infected stems) and severity (based on a scale of 0=no symptoms to 6=dead plant) were recorded at the onset of symptoms (June 24, 2016) and prior to harvest (July 29, 2016). Disease severity index (DSI) values were calculated (incidence x severity) and area under disease progress curves (AUDPC) were calculated using DSI values from both disease readings. Mint hay was harvested from each microplot on July 29, 2016, dried for one week, and weighed. Hay yields were converted to yield ratios by dividing the dry hay yield of each microplot by the mean dry hay yield of the non-inoculated control treatment. A yield ratio > 1 indicated an increased yield compared with the mean yield of the non-inoculated control.

## Results and Discussion

Significant differences in aboveground biomass were not observed among the five green manure treatments, but aboveground biomass of the four mustard treatments (Ida Gold, Pacific Gold, Kodiak, and Caliente 199) were greater than expected, ranging between 13.0 and 19.7 tons/acre; Nemat arugula produced 6.8 tons/acre of biomass (Table 1). The broccoli green manure failed to grow in the microplots and did not produce any biomass during the trial period.

Significant effects of allyl isothiocyanate (AITC) treatment on Verticillium wilt AUDPC were not observed ($P$=0.059); however, all four mustard treatments and arugula significantly reduced *V. dahliae* CFUs compared to the infested/non-treated control (Table 1). Both AITC treatments (10 and 40 gal/acre) reduced *V. dahliae* CFU levels but the reduction was not significant. A small number of *V. dahliae* CFUs were recovered from the non-infested/AITC treatment and mild wilt symptoms were observed, indicating the presence of a background level of inoculum at the trial site. Mint hay yields were not significantly different, but it was notable that hay yields were 1.25 to 1.45 times greater in some green manure treatments (Table 1).

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## Tables

**Table 1.** Effect of green manure and allyl isothiocyanate (AITC) treatments on *Verticillium dahliae* colony forming units (CFU), Verticillium wilt area under disease progress curves (AUDPC), and yield ratios of mint dry hay yields in microplots grown under central Oregon conditions[a]

| **Treatment** | **Green manure yield (tons/acre)** | **CFU/ g soil** | **AUDPC** | **Yield ratio[b]** |
|---|---|---|---|---|
| **Non-infested/non-treated** | N/A[c] | 0.0 a | 0.0 | 1.00 |
| **Infested/non-treated** | N/A | 12.6 c | 43.1 | 1.01 |
| ***Brassica juncea* 'Pacific Gold'** | 15.0 | 2.4 ab | 32.5 | 1.01 |
| ***B. juncea* 'Kodiak'** | 19.7 | 2.4 ab | 15.0 | 1.45 |
| ***Sinapis alba* 'Ida Gold'** | 13.0 | 1.1 a | 42.5 | 1.38 |
| **Caliente 199 mustard blend** | 14.9 | 1.8 ab | 52.5 | 1.37 |
| **Caliente Nemat arugula** | 6.8 | 2.3 ab | 4.4 | 1.25 |
| **95% AITC (10 gal/acre)** | N/A | 9.5 bc | 0.8 | 1.12 |
| **95% AITC (40 gal/acre)** | N/A | 5.1 bc | 1.9 | 1.05 |
| **Non-infested/95% AITC (40 gal/acre)** | N/A | 1.1 a | 3.8 | 0.96 |
| ***P*-value** | 0.1396 | < 0.0001 | 0.0591 | 0.1425 |

[a] Values followed by different letters are significantly different at $P \leq 0.05$

[b] Yield ratio values were calculated by dividing the dry hay yield of each microplot by the mean dry hay yield of the non-inoculated control treatment. A yield ratio > 1 indicates an increased yield compared with the mean yield of the non-inoculated control.

[c] N/A = not applicable