Effects of Formulated Plant Extracts and Oils on Population Density of *Phytophthora nicotianae* in Soil and Control of Phytophthora Blight in the Greenhouse

Phytophthora nicotianae is one of the most widespread and destructive soil borne plant pathogens. This pathogen causes root, stem, and crown rots, as well as fruit and foliar blights from splash dispersal of propagules from soil. Control measures frequently involve targeting the pathogen's propagules in soil with fungicide drenches to reduce initial inoculum. However, disease control options using pesticides are being lost.

Past research has shown that other diseases such as Fusarium wilt can be controlled by soil treated with plant extracts. Combining natural plant extracts and biological control organisms may be a viable strategy to control soil borne pathogens. This experiment evaluated several formulated plant extracts and essential oils for their effectiveness in reducing populations of *P. nicotianae* (Pn-21) and controlling disease development in periwinkle. If natural plant products can reduce populations of soil borne plant pathogens and control disease development, then these plant extracts have a potential as environmentally safe alternatives and as components in integrated pest management programs.

Soil infested with chlamydospores of Pn-21 was treated by incorporating 1, 5, and 10% aqueous formulations containing clove oil, neem oil, pepper extract, mustard oil, cassia extract, synthetic cinnamon oil, or fungicide metalaxyl. Population densities of Pn-21 were determined at 0, 1, 3, 7, 14, and 21 days after treatment. Treatment of the soil with 5 and 10% aqueous emulsions resulted in significant differences among treatment mean values (Table 1) at each date. After 1 day, population densities were reduced below the limit of detection in soil treated with 10% aqueous emulsions of two pepper extract-mustard oil formulations and two cassia extract formulations, and near the limit of detection for a synthetic cinnamon oil formulation. Over time, the populations of Pn-21 were detected in the assay; however, after 21 days, populations of Pn-21 in the soil treated with pepper extract-mustard oil formulations still were not detected. Formulations of clove oil, another pepper extract-mustard oil combination, the two cassia extracts, and synthetic cinnamon oil reduced populations 98.4 to 99.9% after 21 days compared with the control soil. The neem oil formulation and metalaxyl did not reduce pathogen populations at any rate tested. In the greenhouse after 35 days, 10% aqueous emulsions of pepper extract-mustard oil formulations, a cassia extract, and the synthetic cinnamon oil formulations suppressed disease development in periwinkle 93.0 to 96.7% compared to the control soil (untreated and infested). The observed reduction in the pathogen population and significantly more healthy plants in the greenhouse indicates that these formulations of plant extracts and oils could have

important roles in biologically-based management strategies for control of diseases caused by *P. nicotianae*.

Table 1. Soil population densities of *Phytophthora nicotianae* and healthy plant stand of periwinkle growing in infested soil at the conclusion of the experiment as affected by soil treatment with formulated plant extracts and oils or metalaxyl[w]

Rate, Treatment	Population density of *P. nicotianae* (CFU/cm3 of soil)	Percent healthy plant stand (% symptomless plants)
1%		
Not Treated	167.5 cd	0.0
Clove	84.3 e	0.0
Neem	74.3 e	2.5a
Pep/Must 1	262.0 a	0.0
Pep/Must 2	247.3 a	0.0
Cassia 1	129.7 d	0.0
Cassia 2	185.3 abc	…
Cinnamon	107.3 d	0.0
Metalaxyl (low)	171.3 bc	23.8 a
5%		
Not Treated	167.5 b	0.0
Clove	140.3 bc	13.0 b
Neem	77.7 ef	5.0 b
Pep/Must 1	43.5 f	40.0 a
Pep/Must 2	82.5 de	0.0
Cassia 1	134.1 bc	0.0
Cassia 2	191.7 a	…
Cinnamon	27.5 f	33.3 ab
Metalaxyl (medium)	131.3 cd	37.5 a
10%		
Not Treated	167.5 a	0.0
Clove	2.6 c	41.0 b
Neem	105.3 b	3.8 c
Pep/Must 1	<LD	93.3
Pep/Must 2	0.04 d	5.0 c
Cassia 1	0.5 c	93.0 a
Cassia 2	0.7 c	…
Cinnamon	0.4 c	96.7 a
Metalaxyl (high)	117.0 ab	62.5 b

[w] Under each concentration of emulsion, mean values in the same column followed by the same letter are statistically different at P=0.05 for population density experiment and P=0.10 for the disease control experiment based on multiple comparisons of least-square means using the Bonferroni method; <LD = populations of Pn-21 were below the limit of detection in soil dilution assays (0.04 CFU/cm3 of soil).