ABSTRACT

KOHL, LISA MICHELLE. Population dynamics and dispersal gradient of *Aphelenchoides fragariae* in the woody ornamental *Lantana camera*. (Under the direction of D. Michael Benson).

Foliar nematodes (*Aphelenchoides fragariae*) infect ornamental crops in greenhouse and nursery production. The objectives of this research were to study *A. fragariae* population dynamics in a woody ornamental, *Lantana camara*, during the growing season and during overwintering in a commercial nursery, and to determine the dispersal gradient of *A. fragariae* in a nursery with overhead irrigation. In the 2006, 2007, and 2008 growing seasons symptomatic, asymptomatic, and defoliated leaf samples were taken throughout a study plot of 30 lantana plants (*Lantana camara*) infected with foliar nematodes at a commercial nursery in North Carolina. Air temperature, relative humidity, and rainfall data were recorded at the nursery. Over the growing season, nematode densities per gram of fresh weight leaf tissue were low in May and June, and then reached a peak in July, with 122 nematodes/g in July 2006, 406 nematodes/g in July 2007, and 180 nematodes/g in July 2008. Nematode densities decreased over the rest of the summer, except for October 2007 when a second peak occurred. Nematode densities in symptomatic leaves were positively correlated with daily high temperatures and daily low temperatures, while nematode density in asymptomatic leaves were positively correlated to daily low temperatures and relative humidity. Nematode densities in defoliated leaf

samples were positively correlated to relative humidity, daily low temperatures, and daily high temperatures. Leaves were also collected during the 2006-7 and 2007-8 overwintering seasons, when the 30 lantana plants were moved to a polyhouse. During overwintering nematode counts remained low in the three different types of leaf tissue, but nematodes were still detected throughout the overwintering season. In 2007 and 2008 a dispersal gradient for foliar nematodes was examined during the summer at a research nursery by spacing healthy plants at a distance of 0 (touching), 30, or 100 cm from an *A. fragariae*-infected source plant. After 11 weeks in 2007, 100% of the plants at the 0 cm from the inoculum source were infected, while only 10% of the plants at the 30 cm distance and 5% of the plants at the 100 cm distance were infected. In 2008 100% of the plants at the 0 cm spacing became infected after 12 weeks, and 5% of the plants at the 30 cm spacing became infected. No plants at the 100 cm spacing became infected in 2008.

Population dynamics and dispersal gradient of *Aphelenchoides fragariae* in the woody ornamental *Lantana camera*.

by
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Dedication

This thesis is humbly dedicated to my husband, John Almendarez, the great love of my life. His sacrifice, support, and encouragement made it possible for me to complete this great venture. I look forward to an exciting lifetime of many more adventures, and I'm so wonderfully glad that I'll get to experience them all with him by my side.

Biography

Lisa Michelle Kohl was raised in the small rural town of Darien in western New York. She was intrigued by animals, insects, and flowers as a child growing up in the countryside. However, her love of plants truly blossomed after her mother gave her an abandoned garden to care for in the family's yard. From that day on Lisa spent her free time ordering and planting colorful and exotic plants for her garden, and learning as much as she could about plants in general.

Lisa continued studying plant life when she went to college at Cornell University, where she majored in plant sciences with a concentration in plant breeding and genetics. She graduated in 2003 and became the first female field representative to work for the National Grape Cooperative, the cooperative that owns the Welch's Grape Juice Company. At National Grape she worked with over 300 grape growers in Pennsylvania, Ohio, New York, and Ontario, developing a deep appreciation for agriculture and realizing that plant pathogens were a serious problem for growers.

In 2005 Lisa decided to continue her education, and enrolled as a graduate student in plant pathology at North Carolina State University where she studied nematology. Her master's degree research allowed her to work on the epidemiology of foliar nematodes, a widespread disease problem in ornamentals. She married her husband, John Almendarez, in 2007, and they both currently live in North Carolina along with three cats, a dog, and a ferret.

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Literature Review

Introduction:

Foliar nematodes (*Aphelenchoides* spp.) are an increasingly widespread disease in ornamental plants grown in greenhouses, nurseries, and in the landscape. There are three species of economic importance on ornamentals: *Aphelenchoides fragariae* (Ritzema Bos, 1891) Christie, 1932*; Aphelenchoides ritzemabosi* (Schwartz, 1911) Steiner and Buhrer, 1932*;* and *Aphelenchoides besseyi* Christie, 1942. *Aphelenchoides fragariae* is found in a diverse range of plants, including ferns, bedding plants, and herbaceous perennials, and has been reported across the United States (5, 42, 72) *Aphelenchoides ritzemabosi* also attacks a large range of ornamental plant species, but is rarely found on ferns and is commonly found in Europe (29, 67), although neither species is limited to a specific continent. *Aphelenchoides besseyi* is the least common of the three species in ornamentals but has been an economically important pathogen of rice (7). *Aphelenchoides besseyi* prefers warmer climates while *A. ritzemabosi* and *A. fragariae* are more commonly associated with temperate climates, even though these two latter species are actually found in both tropical and temperate localities (74). While all three species have been reported to infect a wide variety of ornamental and crop plants, this review will focus mainly on ornamental plants grown for aesthetic value and *A. fragariae* and *A. ritzemabosi*, the two species that most commonly infect ornamental plants.

Foliar nematodes infect the leaves of plants by migrating up plant stems and entering the stomates of leaves (68). Foliar nematodes feed primarily endoparasitically and occasionally ectoparasitically on plant tissue, depending on the environment and type of plant host (74). During endoparasitic feeding in leaves, foliar nematodes cause brown to black, or chlorotic, vein-delimited lesions that can become necrotic (7). The response of host plants is variable. When the leaves of some woody ornamental plants, such as *Lantana camara*, become heavily infected, defoliation is common. In other plants, such as *Heuchera sanguinea*, the infected leaves eventually turn necrotic and die. The infected leaf tissue of *Hosta* spp. and *Helianthus* spp. drops out leaving a shot-hole or tattered appearance. Because ornamentals are sold for their aesthetic value, these plants are often unsaleable, making foliar nematode damage very costly for ornamental growers.

History and Identification:

The genus *Aphelenchoides* Fischer, 1894, contains many ubiquitous fungal feeding nematode species, as well as species that are parasites of insects and plant pathogens (14). The nematodes in this genus may represent a more primitive type of nematode evolutionarily, because many of these nematodes can feed on both fungi and plants, and the plant parasitic nematodes of the genus have a very wide host range compared to other plant pathogenic nematodes (11). The three most economically important nematodes in this genus are *Aphelenchoides fragariae*, *A. ritzemabosi*, and *A. besseyi*.

Adult nematodes in the genus *Aphelenchoides* are vermiform and about 1 mm in length (53). Plant-parasitic *Aphelenchoides* species can be distinguished from non-plant parasitic *Aphelenchoides* species by the presence of a stylet with basal knobs. *Aphelenchoides* species can be separated from most plant parasitic nematode taxa by the presence of a very large metacarpus, a finely annulated cuticle, an offset lip region, a lateral field that contains two to four lines, and a tapering, conical tail end that is either rounded or has a mucro (14).

Aphelenchoides fragariae was first described when E. A. Ormerod sent infected strawberry plants to Ritzema Bos in England in 1890 (19). The strawberry plants were stunted and deformed so that the crown and lateral branches resembled a cauliflower, which caused Bos to describe the plants as suffering from "cauliflower disease." Bos named the nematodes causing this disease *Aphelenchoides fragariae* in 1891 (19).

Aphelenchoides ritzemabosi had been detected in chrysanthemums suffering from "eelworm disease" as early as 1890, but the nematode was confused with other *Aphelenchoides* species with morphological similarities until Schwartz identified it as *A. ritzemabosi* in 1911 (19). Even after *A. ritzemabosi* was identified as a separate species, *A. ritzemabosi* was still confused with *A. fragariae* due to the morphological similarities between the two species (13). *Aphelenchoides fragariae* has two lateral lines, while *A. ritzemabosi* has a lateral field with four lines (14).

Aphelenchoides besseyi was described by Christie in 1942 (14). This species is often associated with rice plants, where *A. besseyi* causes “white tip” disease in Japan and the southern United States (15). While the most significant plant host for *A. besseyi* is rice, this nematode has also been recorded on many ornamental plant hosts (18). *Aphelenchoides besseyi* can be identified from the other *Aphelenchoides* species by having a lateral field with four lines, a stellate mucro at the tail (14), and shorter postvulvar uterine sac than *A. ritzemabosi* (52).

Molecular tools can also be used to identify *Aphelenchoides* species. Ribosomal DNA been used to differentiate *A. besseyi* and *A. fragariae* from several other *Aphelenchoides* species, including *A. nechaleos*, *A. paranechaleos*, *A. composticola*, *A. bicaudatus*, and *A. arachidis* (24). Chizhov et al. (4) inferred the phylogenetic relationships of *A. fragariae*, *A. ritzemabosi*, and *A. besseyi* to several other *Aphelenchoides* species, and found that plant parasitic species of *Aphelenchoides* grouped together in two clades. A PCR diagnostic assay has been developed to identify *A. fragariae* from infected plant tissue (22), and this PCR assay was able to detect the presence of *A. fragariae* within infected leaf tissue more accurately than a traditional water extraction method (42).

Host Range:

There are over 700 associated host species of foliar nematodes from at least 85 different plant families that are quite diverse (5, 18, 29, 33, 72). This review includes an updated compilation of reported associated hosts of *Aphelenchoides fragariae*, *A. ritzemabosi*, and *A. besseyi* (Table 1). The term "associated host" is used here because Koch's postulates were not performed for all of the references listed. This compilation consolidates associated host lists from around the world, including records from North America, South America, Europe, Asia, and Oceania. This updated list will be of value to diagnostic clinics, researchers, government agencies, and growers who need to know what plants are susceptible to foliar nematode infestation.

The updated host plant list reveals how expansive the foliar nematode host range actually is. A large number of associated plant hosts are members of the plant families Asteraceae, Ranunculaceae, Scrophulariaceae, Primulaceae, Lamiaceae, and Liliaceae, but there are also reports of foliar nematode infecting members of such diverse plant families as Agavaceae, Pinaceae, Poaceae, Orchidaceae, Cactaceae, and Cactaceae. It is also interesting to note that while there are very few reports of *A. ritzemabosi* and *A. besseyi* infecting ferns, there are numerous reports of *A. fragariae* infecting ferns in the families Dryopteridaceae, Pteridaceae, and Aspleniaceae.

The expanded host list also illustrates one of the reasons why control of foliar nematodes is very challenging. Foliar nematodes can quickly spread throughout

greenhouses, infesting many different kinds of plants that are being grown in close vicinity of one another. Management can be especially difficult for growers who specialize in growing small numbers of rare, high-value plants such as exotic ferns or tropical plants. In such cases growers are often reluctant to discard valuable plants that are infected with foliar nematodes, and therefore they allow the nematodes to spread throughout more of their nursery operation. Growers who buy and ship large quantities of plants risk bringing asymptomatic plants infected with foliar nematodes into their operations and can end up contaminating multiple blocks of numerous and varied plants.

Biology:

Water plays a crucial role in the movement and dispersal of foliar nematodes. Dew, rainfall, and overhead irrigation provide the moisture that allows foliar nematodes to migrate in water films over plant surfaces (38). Foliar nematodes migrate up the stems of plants in films of water to reach the leaves that they infect. Wallace (68) observed that *A. ritzemabosi* adults moved fastest in conditions simulating thick films of water that contained epidermal hairs, similar to what would be found on the underside of leaves.

Aphelenchoides spp. enter and exit leaf tissue through the stomata on the leaf undersurface (62, 68). Wallace (68) observed adults of *A. ritzemabosi* entering plant tissue through open stomates on the underside of chrysanthemum leaves. He described the nematode feeling the stomate with its head and then inserting its head into the opening

while moving the rest of its body back and forth until the worm had fully entered the stomate. Wallace (68) also demonstrated that stomata could be the main site of nematode emergence from infected leaves. He did this by covering different surfaces of chrysanthemum leaves with petroleum jelly. Nematodes were able to emerge in large numbers from leaves that had no petroleum jelly at all, or only petroleum jelly applied to the upper surface. However, few nematodes were able to emerge from leaves when the lower surface, where the majority of stomates are present in chrysanthemum leaves, was covered with petroleum jelly (68).

Klinger (32) observed that foliar nematodes were attracted to the tactile stimulus of stomate-shaped slits. The nematodes were not attracted to oxygen, but they were attracted to carbon dioxide gas, which would normally emerge from stomates at night as a result of cellular respiration in the plant. At night there could also be a film of dew over the surface of plant leaves that would allow the nematodes to migrate to the stomates.

After adult and fourth-stage juvenile nematodes enter through leaf stomata, feeding and reproduction occurs within the leaf tissue. The nematodes feed within the mesophyll and epidermis of the leaf (67), piercing neighboring cells with their stylets to feed (62). Eggs are laid within healthy, green sections of the leaf tissues (69). The endoparasitic feeding results in the collapse of the spongy parenchyma and palisade cells, which causes the leaf tissue to turn brown (67). There has also been evidence of the

nematodes feeding ectoparasitically on buds and flower tissues (54), which indicates that the nematodes are able to parasitize plants without entering leaf tissue.

The life cycle is very similar in both *A. ritzemabosi* and *A. fragariae*. Males are required for reproduction, and once females are fertilized they are able to still lay eggs after emergence from months of dormancy in an anhydrobiotic state without refertilization (16). Strümpel (62) observed populations of *A. fragariae* in Lorraine begonia at 18 ^{o}C, and determined that females laid around 32 eggs each, and these eggs hatched in 4 days. The second stage juveniles reached reproductive maturity in 6-7 days. Stewart (59) observed that *A. ritzemabosi* could complete its life cycle in 14 days, with 5 days being required for embryonic development, and maturation occurring after another 5 days; Wallace (69) and French (16) reported similar generation times. Each *A. ritzemabosi* female lays an average of 25-35 eggs in a cluster (69). This means that populations can swell quite quickly within leaf tissue, which may result in thousands of nematodes per gram of leaf tissue within two months time.

Adult and fourth-stage juveniles overwinter by surviving in desiccated plant tissue in an anhydrobiotic state from several months up to three years (7) and have been shown to overwinter in dried leaves, dormant buds, but not plant roots (17, 27). In bare soil the nematodes may be able to survive in a dormant state if the soil is artificially dried, but they do not survive in moist soil watered at up to 30% field capacity (17, 21, 65). Jagdale and Grewal (27) were able to find live nematodes in the soil of overwintering hosta plants,

but the authors did not state if leaf fragments, which would have served as a reservoir for foliar nematodes, could have been present in their soil samples.

Epidemiology:

Foliar nematodes are often dispersed throughout greenhouses and nurseries by splashing water (38). Overheard irrigation allows foliar nematodes to be carried in water droplets to neighboring, uninfected plants. Foliar nematodes can also spread from the direct contact of an infected leaf with uninfected plant tissue. There have been reports of foliar nematodes traveling along weed leaves to infect new plants, in seeds, and in infected leaves that have dehisced and fallen onto uninfected plant tissue (38).

Epidemiology studies on foliar nematodes have been limited. Szczygiel (64) studied populations of *A. fragariae* in field-grown strawberry plants in Poland and determined that the population density of the nematodes in plant parts increased from November to December, and then decreased in January, remaining low through the spring. The highest population density occurred in late autumn, and Szczygiel (64) theorized that the population was responding to changes in the atmospheric temperature and humidity. Szczygiel (66) repeated the experiment in 1967 and 1968, and observed that population densities of *A. ritzemabosi* and *A. fragariae* increased during the early spring and late fall, when the air temperature was low and the humidity was high (66). Yamada and Takakura

(75) examined populations of *A. fragariae* in lilies in Japan, and determined that the population density of nematodes in the leaves increased during the rainy season.

More research needs to be conducted on the spatial and temporal epidemiology of foliar nematodes in order to better understand the population dynamics of these nematodes and develop more effective management tactics.

Management:

Foliar nematode management is very challenging. Because foliar nematodes are disseminated by splashing water, a common recommendation is to avoid overhead irrigation systems. Unfortunately, this is often very difficult for growers to do, especially when costly overhead irrigation systems are already in place for large sections of greenhouse space. In an outdoor nursery setting, rain events can spread foliar nematodes, so changing the irrigation system alone will not be sufficient to prevent nematode spread.

Some cultivars of chrysanthemums have been reported to have foliar nematode resistance (20). These cultivars have leaves that brown and turn necrotic at faster rates than other cultivars, which causes the foliar nematodes to become surrounded by dead cells and prevents the nematodes from being able to feed on green tissue, causing reduced egg laying in females (70). However, no breeding work has been done to produce foliar nematode resistant chrysanthemum plants using this information. Even if there were breeding programs to produce plants that were resistant to foliar nematodes, it would be

impossible to introduce resistance into all of the hundreds of plant species that are susceptible to foliar nematodes.

In the past, chemical treatments such as oxamyl and parathion were used for effective management of foliar nematodes (28). However, due to environmental concerns, the chemicals that were used in the past are no longer available to growers today, and modern chemical control methods have variable results, depending on the plant being treated. Chemical treatments tested may be successful at killing nematodes in a water suspension, but then fail to control nematodes when applied to infected leaves (25). A miticide containing the active ingredient chlorfenapyr is currently labeled for foliar nematode control on greenhouse ornamentals. Chlorfenapyr has been reported to be successful at reducing foliar nematode populations in thin-leaved plants such as anemone (49) but is not as effective in crops with thicker leaves such as lantana (71). Other insecticides have been tested for control of foliar nematodes with similar results (36). These findings suggest that current chemical treatments may not effective at controlling foliar nematodes on all plants because the chemicals are unable to fully penetrate leaf tissue to reach the nematodes on many plant species and emphasize the need for effective chemical controls that are truly systemic within the plant.

An alternative method for foliar nematode management that can effectively kill nematodes within leaf tissue is soaking infected plants in hot water baths. Staniland (58) concluded that *A. ritzemabosi* could be killed in chrysanthemum stock plants soaked in

water at a temperature of 46 ^{o}C for 5 minutes. Jagdade and Grewal (26) found that submerging infected hostas in 90 ^{o}C water in the spring or autumn could greatly reduce *A. fragariae* populations. However, this method is very labor intensive, and there can be negative effects on the growth of some plants after being submerged in the hot water, so this method is often used only as a last resort in commercial settings, or only for high value crops.

Future Work:

While much of the basic biology of *Aphelenchoides* has been determined, there is still a great deal of research that needs to be done to understand *Aphelenchoides* epidemiology. We need a better understanding of intra- and inter-plant distribution, dispersal of foliar nematodes in ornamental plant systems, and the infection process to be able to develop integrated management strategies for foliar nematode control in greenhouses and nurseries. Breeding programs can provide resistance to a small number of ornamental plants, but the host range for *Aphelenchoides* is wide and variable. More comprehensive *Aphelenchoides* research efforts should focus on epidemiological studies to develop methods to prevent infected plants from infecting other plants and to effectively utilize chemical controls, biological controls, sanitation techniques, and other strategies to control existing infections of foliar nematodes in infected plants.

Literature Cited:

1. Banck, A. 1974. Leaf nematode on Streptocarpus. Vaxtskyddnotiser 38:52-54.

2. Brinkman, H. 1975. Nematological observations in 1973 and 1974. Gewasbescherming 6:57-64.

3. Chakraborti, H.S., and Ghosh, S.C. 1993. Studies on the floral malady of *Polianthes tuberosa* L. in West Bengal. Journal of Mycopathological Research 31:109-115.

4. Chizhov, V.N., Chumakova, O.A., Subbotin, S.A., and Baldwin, J.G. 2006. Morphological and molecular characterization of foliar nematodes of the genus Aphelenchoides: *A. fragariae* and *A. ritzemabosi* (Nematoda : Aphelenchoididae) from the Main Botanical Garden of the Russian Academy of Sciences, Moscow. Russian Journal of Nematology 14:179-184.

5. Crossman, L., and Christie, T.R. 1936. A list of plants attacked by the leaf nematode (*Aphelenchoides fragariae*). Plant Disease Reporter 20:155-165.

6. Dale, P.S. 1972. List of plant hosts of nematodes in New-Zealand. New Zealand Journal of Science 15:442-448.

7. Daughtrey, M.L., Wick, R.L., and Peterson, J.L. 1995. *Compendium of flowering potted plant diseases*. St. Paul, MN: APS Press.

8. DPI. 1988. Division of Plant Industry: Florida Department of Agirculture and Consumer Services.

9. DPI. 1990. Division of Plant Industry: Florida Department of Agriculture and Consumer Services.

10. DPI. 1992. Division of Plant Industry: Florida Department of Agirculture and Consumer Services.

11. Dropkin, V.H. 1980. *Introduction to Plant Nematology*. New York: John Wiley & Sons.

12. Esser, R.P., O'Bannon, J.H., and Clark, R.A. 1988. Procedures to detect foliar nematodes for annual nursery or out of state inspections. In *Nematology Circular*: Florida Department of Agriculture & Consumer Services.

13. Franklin, M.T. 1950. Two species of *Aphelenchoides* associated with strawberry bud disease in Britain. Annals of Applied Biology 37:1-10.

14. Franklin, M.T. 1978. *Aphelenchoides* and related genera. Pages 172-187. In *Plant Nematology*, edited by Southey, J. F. London: Her Majesty's Stationery Office.

15. Franklin, M.T., and Siddiqi, M.R. 1972. *Aphelenchoides besseyi*. *Commonwealth Institute of Helminthology Descriptions of Plant-Parasitic Nematodes, Set 1, No. 4.* Kew, England: Commonwealth Agricultural Bureaux.

16. French, N., and Barraclough, R.M. 1961. Observations on the reproduction of *Aphelenchoides ritzemabosi* (Schwartz). Nematologica 6:89-94.

17. French, N., and Barraclough, R.M. 1962. Survival of *Aphelenchoides ritzemabosi* (Schwartz) in soil and dry leaves. Nematologica 7:309-316.

18. Goodey, J.B., Franklin, M.T., and Hooper, D.J. 1965. *T. Goodey's The nematode parasites of plants catalogued under their hosts*. Bucks, England: Farmham Royal.

19. Goodey, T. 1933. *Plant parasitic nematodes and the diseases they cause*. Methuen, London.

20. Hesling, J.J., and Wallace, H.R. 1961. Observations on the susceptibility of chrysanthemum varieties infested at two different times with chrysanthemum eelworm, *Aphelenchoides ritzemabosi*. Nematologica 6:64-68.

21. Hesling, J.J., and Wallace, H.R. 1961. Observations on the biology of chrysanthemum eelworm *Aphelenchoides ritzema-bosi* (Schwartz) Steiner in florists' chrysanthemum. I. Spread of eelworm infestation. Annuals of Applied Biology 49:195-203.

22. Hudson, L.C., Wang, X., Davis, E.L., and Warfield, C.Y. 2004. Development of a PCR-based detection assay for foliar nematodes (*Aphelenchoides* spp.). Phytopathology 94:S43.

23. Hunter, J.E., Ko, W.H., Kunimoto, R.K., and Higaki, T. 1974. A foliar disease of anthurium seedlings caused by *Aphelenchoides fragariae*. Phytopathology 64:267-268.

24. Ibrahim, S.K., Perry, R.N., Burrows, P.R., and Hooper, D.J. 1994. Differentiation of species and populations of *Aphelenchoides* and of *Ditylenchus angustus* using a fragment of ribosomal DNA. Journal of Nematology 26:412-421.

25. Jagdale, G.B., and Grewal, P.S. 2002. Identification of alternatives for the management of foliar nematodes in floriculture. Pest Management Science 58:451-458.

26. Jagdale, G.B., and Grewal, P.S. 2004. Effectiveness of a hot water drench for the control of foliar nematodes *Aphelenchoides fragariae* in floriculture. Journal of Nematology 36:49-53.

27. Jagdale, G.B., and Grewal, P.S. 2006. Infection behavior and overwintering survival of foliar nematodes, *Aphelenchoides fragariae*, on Hosta. Journal of Nematology 38:130-136.

28. Johnson, A.W., and Grill, D.L. 1975. Chemical control of foliar nematodes (*Aphelenchoides fragariae*) on 'Fluffy Ruffles' fern. Plant Disease Reporter 59:772-774.

29. Juhl, V.M. 1978. Liste over vaertplanter for bladnematoden *Aphelenchoides ritzemabosi*. Ugeskr. f. Agron., Hort., Forst., og Lic. 123:183-186.

30. Kermarrec, A., and Anais, A. 1974. Presence of *Aphelenchooides besseyi* in foliage and tubers of yam (*Discorea trifida*) in the French West Indies. Nematropica 4:2-3.

31. Khakimova, L. 1981. The nematodes of *Matricaria grandiflora*. Uzbekskii Biologicheskii Zhurnal 2:42-44.

32. Klingler, J. 1970. The Reaction of *Aphelenchoides fragariae* to Slit-Like Micro-Openings and to Stomatal Diffusion Gases. Nematologica 16:417-422.

33. Knight, K.W.L., Barber, C.J., and Page, G.D. 1997. Plant-parasitic nematodes of New Zealand recorded by host association. Journal of Nematology 29:640-656.

34. Knight, K.W.L., Hill, C.F., and Sturhan, D. 2002. Further records of *Aphelenchoides fragariae* and *A. ritzemabosi* (Nematoda:Aphelenchida) from New Zealand. Australasian Plant Pathology 31:93-94.

35. LaMondia, J.A. 1995. First report of the foliar nematode *Aphelenchoides fragariae* infecting *Lamium*. Plant Disease 79:642.

36. LaMondia, J.A. 1999. Efficacy of insecticides for control of *Aphelenchoides fragariae* and *Ditylenchus dipsaci* in flowering perennial ornamentals. Journal of Nematology 31:644-649.

37. Lehman, P.S. 1992. Bureau of nematology: detections of special interest. Tri-ology Technical Report 31:3-4.

38. Lehman, P.S. 1996. Dispersal modes for foliar nematodes. In *Nematology Circular 216*: Florida Department of Agriculture & Consumer Services.

39. Locascio, S.J., Smart, G.C., and Marvel, M.E. 1967. Control of bud nematode on strawberry. Proceedings of the Florida State Horticultural Society 79:170-175.

40. Marlatt, R.B. 1966. *Fiscus elastica* a host of *Aphelenchoides besseyi* in a subtropical climate. Plant Disease Reporter 50:689-691.

41. Matveeva, M.A. 1976. Aphelenchoides infection of Saintpaulia magungensis. Okhrana okruzhaiushchei sredy i ratsional'noe ispol'zovanieprirodnykh resursov 1976:288.

42. McCuiston, J.L., Hudson, L.C., Subbotin, S.A., Davis, E.L., and Warfield, C.Y. 2007. Conventional and PCR detection of *Aphelenchoides fragariae* in diverse ornamental host plant species. Journal of Nematology 39:343-355.

43. Mead, F.W. 1989. Buraeu of nematology. Tri-ology Technical Report. Gainesville, FL: Florida Department of Agriculture and Consumer Services, Division of Plant Industry.

44. Meredith, J.A., and Yepez, T.G. 1973. Presence of *Aphelenchoides ritzemabosi* (Schwartz, 1911) Steiner, 1932 on a commerical planting of tuberose (*Polianthes tuberosa* L.) in Venezuela. Nematropica 3:28.

45. Mor, M., and Spiegel, Y. 1993. *Ruscus hypophyllum*: A new host for *Aphelenchoides fragariae*. Journal of Nematology 25:312-313.

46. Noel, G.R., and White, D. 1994. *Hosta*: A new host record for *Aphelenchoides fragariae*. Plant Disease 78:924.

47. Penrose, L.J., and Nikandrow, A. 1971. Ficus macrophylla, a new host for Apehelenchoides fragariae (Ritzema Bos) Christie. Search 2:170.

48. Raabe, R.D. 1991. New disease problems on ornamental plants in California. Combined Proceedings International Plant Propagator's Society 40:160-162.

49. Rechcigl, N. 2003. What works best for pest management: a focus on mite management and foliar nematodes. Proceedings of the Annual Conference on Pest and Disease Management for Ornamentals, at Orlando.

50. Revilla, E.P., Sastroutomo, S.S., and Rahim, M.A.A. 1991. Survey on aquarium plants of quarantine importance and their associated nematodes. BIOTROP Special Publication 40:205-215.

51. Roberts, H. 1981. New or unusual host plant records for plant parasitic nematodes 1977-80. Plant Pathology 30:182.

52. Sanwal, K.C. 1961. A key to the species of the nematode genus *Aphelenchoides* Fischer, 1894. Canadian Journal of Zoology 39:143-148.

53. Shurtleff, M.C., and Averre, C.W. 2000. *Diagnosing Plant Diseases Caused by Nematodes*. St. Paul, MN: APS Press.

54. Siddiqi, M.R. 1975. *Aphelenchoides fragariae*. *Commonwealth Institute of Helminthology Descriptions of Plant-Parasitic Nematodes, no. 74.* Kew, England: Commonwealth Agricultural Bureaux.

55. Smart, G.C., and Esser, R.P. 1968. *Aphelenchoides fragariae* in aquatic plants. Plant Disease Reporter 52:455.

56. Southey, J.F., and Roberts, H. 1974. New or unusual host plant records for plant parasitic nematodes, 1971-1973. Plant Pathology 23:45-46.

57. Southey, J.F., and Roberts, H. 1977. New or unusual host plant records for plant parasitic nematodes. Plant Pathology 26:148.

58. Staniland, L.N. 1950. Experiments on the control of chrysanthemum eelworm (*Aphelenchoides ritzema-bosi*, Schwartz) by hot water treatment. Ann. Appl. Biol 37:11-18.

59. Stewart, F.H. 1921. The anatomy and biology of the parasitic Aphelenchi. Parasitology 13:160-179.

60. Stokes, D.E. 1967. Newly reported fern hosts of *Aphelenchoides fragariae* in Florida. Plant Disease Reporter 51:508.

61. Stokes, D.E. 1979. Plant symptoms associated with *Aphelenchoides* spp. In Florida. In *Nematology Circular*: Florida Department of Agriculture & Consumer Services.

62. Strumpel, H. 1967. Beobachtungen zur Lebensweise von *Aphelenchoides fragariae* in Lorraine-Begonien. Nematologica 13:67-72.

63. Suatmadji, R.W. 1983. *Aphelenchoides fragariae* on ferns in nurseries and natural forests in Victoria. Australasian Plant Pathology 12:62-64.

64. Szczygiel, A. 1966. Studies on the fauna and population dynamics of nematodes occurring on strawberry plantations. Ekologia Polska 14:651-709.

65. Szczygiel, A., and Hasior, H. 1971. Possibility of persistence of leaf and bud nematodes (*Aphelenchoides fragariae*) on strawberry plants and in the soil. Zeszyty problemowe postepow nauk rolniczych 121:101-106.

66. Szczygiel, A., and Hasior, H. 1972. Seasonal variations in population of plant parasitic nematodes in strawberry plantations. Ekologia Polska 20:507-522.

67. Volvas, N., Minuto, A., Garibaldi, A., Troccoli, A., and Lamberti, F. 2005. Identification and histopathology of the foliar nematode *Aphelenchoides ritzemabosi* (Nematoda: Apehelenchoididae) on basil in Italy. Nematology 7:301-308.

68. Wallace, H.R. 1959. Movement of eelworms. V. Observations on *Aphelenchoides ritzema-bosi* (Schwartz 1912) Steiner 1932 on florists' chrysanthemums. Annals of Applied Biology 47:350-360.

69. Wallace, H.R. 1960. Observations on the behaviour of *Aphelenchoides ritzema-bosi* in chrysanthemum leaves. Nematologica 5:315-321.

70. Wallace, H.R. 1961. The nature of resistance in chrysanthemum varieties to *Aphelenchoides ritzemabosi*. Nematologica 6:49-58.

71. Warfield, C.Y., Parra, G.R., and Dudley, J.B. 2004. Efficacy of miticides and a disinfestant for foliar nematode control on lantana and buddleia, 2003. In *Fungicide and Nematicide Tests (online).* St. Paul, MN: Am. Phytopathology Society.

72. Wick, R.L. 1995. Occurrence of foliar nematodes on woodland plants in a Massachusetts native plant garden. Phytopathology 85:1561.

73. Windham, A.S., Conlon, H.P., and Windham, M. 2005. Foliar nematodes and perennial plants: the silent epidemic. Southern Nursery Association Research Conference 50:282-284.

74. Winslow, R.D. 1960. Nematode ecology. *Nematology: Fundamentals and recent advances with emphasis on plant parasitic and soil forms*, edited by Sasser, J. N. and Jenkins, W. R. Chapel Hill: The University of North Carolina Press.

75. Yamada, E., and Takakura, S. 1987. Ecological investigations on the strawberry nematode, *Aphelenchoides fragariae* on lilies. Japanese Journal of Nematology 17:1-7.

76. Zhang, Y.C. 1989. Studies on the occurrence and development of potted chulan tree leaf-spot disease caused by *Aphelenchoides besseyi*. Acta Agriculturae Shanghai 5:69-74.

Table 1. Reported plant hosts of *Aphelenchoides fragariae*, *A. ritzemabosi*, and *A. besseyi*.

Host Genus	Host Species	Common Name	Host Family	Nematode Species	References
Abelia	*x. grandiflora* (Rovelli ex André) Rehd.	glossy abelia	*Caprifoliaceae*	*A. fragariae*	(42)
Achillea	*filipendulina* Lam.	fernleaf yarrow	*Asteraceae*	*A. ritzemabosi*	(18)
Achillea	*millefolium* L.	milfoil, common yarrow	*Asteraceae*	*A. ritzemabosi*	(29)
Achimenes	*spp.*	magic flowers, widow's tears	*Gesneriaceae*	*A. fragariae*	(2)
Aconitum	*lycoctonum* L.	monkshood, wolfsbane	*Ranunculaceae*	*A. fragariae*	(18)
Aconitum	*napellus* L.	monkshood, aconite, blue-rocket	*Ranunculaceae*	*A. ritzemabosi*	(18)
Acrostichum	*flagelliferum* WALL.		*Pteridaceae*	*A. fragariae*	(18)
Actaea	*japonica* Thunb.		*Ranunculaceae*	*A. fragariae*	(72)
Actaea	*pachypoda* Elliott	white baneberry, doll's-eyes, white cohosh	*Ranunculaceae*	*A. fragariae*	(72)
Actaea	*rubra* (Aiton.) Willd.	red baneberry, snakeberry	*Ranunculaceae*	*A. fragariae*	(72)
Actaea	*spicata* L.	baneberry	*Ranunculaceae*	*A. fragariae*	(18)
Adenostyles	*alpina* (L.) Bluff & Fingerh.		*Asteraceae*	*A. ritzemabosi*	(5, 29)
Adiantum	*aethiopicum* L.	common maidenhair fern	*Pteridaceae*	*A. fragariae*	(18)
Adiantum	*anceps* Maxon & C. V. Morton	double edge maidenhair fern	*Pteridaceae*	*A. fragariae*	(8)
Adiantum	*capillus-veneris* L.	southern maidenhair, Venus maidenhair, Venus' hair fern	*Pteridaceae*	*A. fragariae*	(5)
Adiantum	*pedatum* L.	northern maidenhair fern, five-finger fern, pointerweed	*Pteridaceae*	*A. fragariae*	(72)
Adiantum	*peruvianum* Klotzsch	silver dollar maidenhair fern	*Pteridaceae*	*A. fragariae*	(18)

Table 1. Continued

Adiantum	*polyphyllum* Willd.	giant maidenhair fern	*Pteridaceae*	*A. fragariae*	(18)
Adiantum	*seemanii* Hook		*Pteridaceae*	*A. fragariae*	(12)
Adiantum	*tenerum* Sw.	brittle maidenhair, fan maidenhair fern	*Pteridaceae*	*A. fragariae*	(5)
Adiantum	*trapeziforme* L.	diamond maidenhair, giant maidenhair fern	*Pteridaceae*	*A. fragariae*	(5)
Adiantum	*spp.*		*Pteridaceae*	*A. fragariae*	(8)
Aegopodium	*podagraria L.*	bishop's weed, ashweed, goutweed	*Apiaceae*	*A. ritzemabosi*	(18)
Agastache	*spp.*		*Lamiaceae*	*A. fragariae*	(42)
Agastache	*foeniculum* (Pursh) Kuntze	blue giant hyssop, anise hyssop, licorice-mint	*Lamiaceae*	*A. fragariae*	(42)
Ageratum	*conyzoides* L.	tropical whiteweed, billygoat-weed, goatweed	*Asteraceae*	*A. fragariae*	(18)
Ageratum	*houstonianum* Mill.	ageratum, bluemink, blue billygoat-weed	*Asteraceae*	*A. ritzemabosi*	(18)
Alchemilla	*mollis* (Buser) Rothm.	lady's-mantle	*Rosaceae*	*A. ritzemabosi*	(34)
Allium	*flavum* L.	yellow onion	*Liliaceae*	*A. ritzemabosi*	(29)
Allium	*sativum* L.	cultivated garlic	*Liliaceae*	*A. ritzemabosi*	(18)
Allium	*sikkimense* Baker	chives, ornamental onion	*Liliaceae*	*A. ritzemabosi*	(29)
Alstroemeria	*spp.*	lily of the Incas	*Alstroemeriaceae*	*A. ritzemabosi, A. fragariae*	(34)
Amaranthus	*spp.*	pigweed	*Amaranthaceae*	*A. ritzemabosi*	(6)
Ampelopsis	*quinquefolia* (L.) Planch.	Virginia creeper	*Vitaceae*	*A. ritzemabosi*	(18)
Anacyclus	*pyrethrum* (L.) Link	Spanish pellitory	*Asteraceae*	*A. ritzemabosi*	(18)
Anchusa	*caespitosa* Lam.	tufted anchusa	*Boraginaceae*	*A. fragariae*	(18)
Anemia	*collina* Raddi		*Anemiaceae*	*A. fragariae*	(5)
Anemia	*phyllitidis* (L.) Sw.		*Anemiaceae*	*A. fragariae*	(5)
Anemia	*tomentosa* (Savigny) Sw.	hairy flowering fern	*Anemiaceae*	*A. fragariae*	(42)

Table 1. Continued

Anemone	*alpina* L.	alpine windflower	*Ranunculaceae*	*A. fragariae*	(18)
Anemone	*angulosa* Lam.		*Ranunculaceae*	*A. fragariae*	(18)
Anemone	*coronaria* L.	lilies-of-the-field	*Ranunculaceae*	*A. ritzemabosi, A. fragariae*	(18)
Anemone	*flaccida* F. Schmidt		*Ranunculaceae*	*A. fragariae*	(18)
Anemone	*halleri* All.		*Ranunculaceae*	*A. fragariae*	(18)
Anemone	*hepatica* L.		*Ranunculaceae*	*A. ritzemabosi, A. fragariae*	(5, 29)
Anemone	*hupehensis* Lemoine var. *hupehensis*		*Ranunculaceae*	*A. fragariae*	(18)
Anemone	*hupehensis* Lemoine var. *japonica* (Thunb.) Bowles & Stearn	Japanese anemone, Japanese windflower	*Ranunculaceae*	*A. fragariae*	(5)
Anemone	*nemorosa* L.	European wood anemone, European thimbleweed	*Ranunculaceae*	*A. fragariae*	(5)
Anemone	*ranunculoides* L.		*Ranunculaceae*	*A. fragariae*	(18)
Anemone	*sylvestris* L.	snowdrop windflower	*Ranunculaceae*	*A. ritzemabosi, A. fragariae*	(5, 29)
Anemone	*vitifolia* Buch.-Ham. ex DC.		*Ranunculaceae*	*A. fragariae*	(18)
Anemone	*x hybrida* Paxton	Japanese anemone	*Ranunculaceae*	*A. ritzemabosi, A. fragariae*	(33)
Angelica	*gigas* Nakai	Korean angelica	*Apiaceae*	*A. fragariae*	(42)
Anigozanthos	*spp.*	kangaroo paws	*Haemodoraceae*	*A. fragariae*	(48)
Anthemis	*nobilis* L.	Roman chamomile	*Asteraceae*	*A. ritzemabosi*	(18)
Anthemis	*tinctoria* L.	golden chamomile, golden marguerite, yellow chamomile	*Asteraceae*	*A. ritzemabosi*	(18)
Anthriscus	*sylvestris* (L.) Hoffmann	wild chervil, cow-parsley, keck	*Apiaceae*	*A. ritzemabosi*	(18)
Anthurium	*acaule* (Jacq.) Schott		*Araceae*	*A. fragariae*	(12)

Table 1. Continued

Anthurium	*andraeanum* Linden ex André	flamingo-lily, oilcloth-flower	*Araceae*	*A. fragariae*	(23)
Anthurium	*salviniae* Hemsl.		*Araceae*	*A. fragariae*	(12)
Anthurium	*scherzerianum* Schott	flamingo flower	*Araceae*	*A. ritzemabosi*	(29)
Antirrhinum	*majus* L.	snapdragon	*Scrophulariaceae*	*A. ritzemabosi*	(18)
Apium	*graveolens* L.	celery	*Apiaceae*	*A. ritzemabosi*	(18)
Aquilegia	*longissima* A. Gray ex S. Watson	longspur columbine	*Ranunculaceae*	*A. ritzemabosi*	(18)
Aquilegia	*vulgaris* L.	columbine, European columbine, granny's-bonnet	*Ranunculaceae*	*A. ritzemabosi*	(33)
Arabis	*aubrietioides* Boiss.	rockcress	*Brassicaceae*	*A. ritzemabosi*	(18)
Arachniodes	*simplicior* (Makino) Ohwi	simpler hollyfern	*Dryopteridaceae*	*A. fragariae*	(42)
Araujia	*sericifera* Brot.	white bladderflower, cruelplant, moth-catcher	*Asclepiadaceae*	*A. fragariae*	(33)
Argyranthemum	*frutescens* (L.) Sch. Bip.	marguerite, Paris daisy, white marguerite	*Asteraceae*	*A. fragariae*	(5)
Arisaema	*amurense* Maxim.		*Araceae*	*A. fragariae*	(18)
Arisaema	*ringens* (Thunb.) Schott.	cobra lily	*Araceae*	*A. fragariae*	(18)
Artemisia	*vulgaris* L.	artemisia, common wormwood, mugwort	*Asteraceae*	*A. ritzemabosi*	(29)
Arthropodium	*cirrhatum* (G. Forst.) R. Br.	rock lily	*Liliaceae*	*A. fragariae*	(33)
Asarum	*canadense* L.	American wild ginger, Canadian snakeroot, wild ginger	*Aristolochiaceae*	*unknown species*	(73)
Asarum	*europaeum* L.	European wild ginger, asarabacca	*Aristolochiaceae*	*A. ritzemabosi*	(29)
Asarum	*maximum* Hemsl.	giant wild ginger	*Aristolochiaceae*	*A. fragariae*	(42)
Aspidium	*barteri* J.Sm.		*Dryopteridaceae*	*A. fragariae*	(18)

Table 1. Continued

Asplenium	*adiantum-nigrum* L.	black spleenwort	*Aspleniaceae*	*A. fragariae*	(18)
Asplenium	*bulbiferum* G. Forst.	mother spleenwort, mother fern	*Aspleniaceae*	*A. fragariae*	(18, 33)
Asplenium	*ceterach* L.		*Aspleniaceae*	*A. fragariae*	(18)
Asplenium	*daucifolium* Lam.	Mauritius spleenwort	*Aspleniaceae*	*A. fragariae*	(12)
Asplenium	*decussatum* Sw.		*Aspleniaceae*	*A. fragariae*	(18)
Asplenium	*dimorphum* Kunze		*Aspleniaceae*	*A. fragariae*	(18)
Asplenium	*diversifolium* Bl.		*Aspleniaceae*	*A. fragariae*	(5)
Asplenium	*dumosis*		*Aspleniaceae*	*A. ritzemabosi*	(33)
Asplenium	*jamaicense* Jenm.		*Aspleniaceae*	*A. besseyi, A. fragariae*	(12)
Asplenium	*nidus* L.	birdnest fern, nest fern	*Aspleniaceae*	*A. ritzemabosi, A. fragariae*	(18)
Asplenium	*oblongifolium* Colenso.	New Zealand shining spleenwort	*Aspleniaceae*	*A. fragariae*	(33)
Asplenium	*scolopendrium* L. var. *americanum* (Fernald) Kartesz & Gandhi	American hart's tongue fern	*Aspleniaceae*	*A. fragariae*	(18)
Asplenium	*spp.*		*Aspleniaceae*	*A. fragariae*	(29)
Asplenium	*squamosum* L.		*Aspleniaceae*	*A. fragariae*	(12)
Asplenium	*trichomanes* L.	maidenhair spleenwort	*Aspleniaceae*	*A. fragariae*	(18)
Aster	*alpinus* L.	alpine aster	*Asteraceae*	*A. ritzemabosi, A. fragariae*	(18)
Aster	*caucasicus* Willd.		*Asteraceae*	*A. ritzemabosi*	(18)
Aster	*pattersonii* Gray	Bigelow's tansyaster	*Asteraceae*	*A. fragariae*	(18)
Aster	*spp.*		*Asteraceae*	*A. fragariae*	(5)
Aster	*tripolium* L.	sea aster, sea starwort	*Asteraceae*	*A. ritzemabosi*	(29)
Astilbe	*astilboides* (Maxim.) Lemoine	astilbe	*Saxifragaceae*	*A. fragariae*	(5)

Table 1. Continued

Astrantia	*biebersteinii* Fisch. & Mey.		*Apiaceae*	*A. fragariae*	(18)
Astrantia	*carniolica* Jacq.	dwarf masterwort	*Apiaceae*	*A. fragariae*	(18)
Astrantia	*major* L.	astrantia, greater masterwort	*Apiaceae*	*A. fragariae*	(18)
Athyrium	*felix-femina* (L.) Roth ex Mert.	common ladyfern	*Dryopteridaceae*	*A. fragariae*	(42)
Athyrium	*umbrosum* (Ait.) Presl.		*Dryopteridaceae*	*A. fragariae*	(18)
Barleria	*cristata* L.	barureria, crested Philippine violet	*Acanthaceae*	*A. ritzemabosi, A. fragariae*	(18)
Begonia	*cucullata* Willd. var. *cucullata*	wax begonia	*Begoniaceae*	*A. fragariae*	(5)
Begonia	*dregei* Otto & Dietrich	grape-leaf begonia, maple-leaf begonia	*Begoniaceae*	*A. fragariae*	(12)
Begonia	*foliosa Kunth var. miniata (Planch. & Linden) L. B. Sm. & B. G. Schub.*	fuchsia begonia	*Begoniaceae*	*A. ritzemabosi*	(29)
Begonia	*rex* Putz.	rex begonia, king begonia, painted-leaf begonia	*Begoniaceae*	*A. fragariae*	(5)
Begonia	*x hiemalis* Fotsch	rieger begonia, winter-flowering begonia, elatior begonia	*Begoniaceae*	*A. fragariae*	(18)
Begonia	*rex-cultorum* L.H. Bailey	cultivated rex begonia, beefsteak-geranium	*Begoniaceae*	*A. fragariae*	(12)
Bellis	*perennis* L.	daisy, English daisy	*Asteraceae*	*A. ritzemabosi*	(18)
Bergenia	*crassifolia* (L.) Fritsch	Siberian tea	*Saxifragaceae*	*A. fragariae*	(18, 33)
Bergenia	*pacumbis* (Buch.-Ham. ex D. Don) C. Y. Wu & J. T. Pan		*Saxifragaceae*	*A. fragariae*	(18)
Bergenia	*purpurascens* (Hook. f. & Thomson) Engl.		*Saxifragaceae*	*A. fragariae*	(18)
Bergenia	*spp.*		*Saxifragaceae*	*A. ritzemabosi*	(51)
Blainvillea	*acmella* (L.) Philipson		*Asteraceae*	*A. ritzemabosi*	(18)

Table 1. Continued

Blechnum	*brasiliense* Desv.		*Blechnaceae*	*A. fragariae*	(5)
Blechnum	*cartilagineum* Swartz	gristle fern	*Blechnaceae*	*A. fragariae*	(18)
Blechnum	*fraxineum* Willd.		*Blechnaceae*	*A. fragariae*	(5)
Blechnum	*gibbum* (Lab.) Mett.	silver lady fern, dwarf tree fern	*Blechnaceae*	*A. fragariae*	(5)
Blechnum	*moorei* C.Chr.	Brazilian tree fern	*Blechnaceae*	*A. fragariae*	(5)
Blechnum	*patersonii* (R.Br.) Mett.	Strap water fern	*Blechnaceae*	*A. fragariae*	(33)
Bletilla	*striata* (Thunb.) Rchb.f.	hyacinth orchid, peacock orchid	*Orchidaceae*	*A. fragariae*	(18)
Bolbitis	*heteroclita* (C. Presl) Ching		*Dryopteridaceae*	*A. fragariae*	(5)
Bouvardia	*longiflora* (Cav.) Kunth		*ritzemabosi*	*A. fragariae*	(33)
Bouvardia	*spp.*		*Rubiaceae*	*A. fragariae*	(5)
Boykinia	*aconitifolia* Nutt.		*Saxifragaceae*	*A. fragariae*	(18)
Brassica	*oleracea* L. var. *capitata* L.	cabbage, red cabbage, white cabbage	*Brassicaceae*	*Aphelenchoides*	(5)
Brunnera	*macrophylla* (Adams) I. M. Johnst.	brunnera, perrenial forget-me-not, Siberian bugloss	*Boraginaceae*	*A. ritzemabosi, A. fragariae*	(18)
Buddleja	*alternifolia* Maxim.		*Buddlejaceae*	*A. ritzemabosi*	(29)
Buddleja	*colvilei* Hook. f. & Thomson		*Buddlejaceae*	*A. ritzemabosi*	(29)
Buddleja	*davidii* Franch.	butterfly bush, summer lilac, orange-eye	*Buddlejaceae*	*A. fragariae*	(33)
Buddleja	*davidii* Franch.	butterfly bush, summer lilac, orange-eye	*Buddlejaceae*	*A. ritzemabosi*	(18)
Buddleja	*fallowiana* Balf. f. & W. W. Sm.		*Buddlejaceae*	*A. ritzemabosi*	(29)
Buddleja	*globosa* Hope	orange ball tree	*Buddlejaceae*	*A. ritzemabosi*	(29)
Bunias	*orientalis* L.	hill mustard	*Brassicaceae*	*A. ritzemabosi*	(18)
Cabomba	*caroliniana* A. Gray	Carolina fanwort, Carolina water shield, fish grass	*Cabombaceae*	*A. fragariae*	(12)

Table 1. Continued

Calamintha	*nepeta* (L.) Savi	lesser calamint	*Lamiaceae*	*A. fragariae*	(18)
Calceolaria	×*herbeohybrida* Voss	pocketbook flower, pocketbook plant, slipperflower	*Scrophulariaceae*	*A. ritzemabosi*	(29)
Calceolaria	*spp.*		*Scrophulariaceae*	*A. fragariae*	(5)
Calendula	*officinalis* L.	calendula, marigold, pot marigold	*Asteraceae*	*A. ritzemabosi*	(18)
Callistephus	*chinensis* (L.) Nees	annual aster, China aster	*Asteraceae*	*A. ritzemabosi*	(5, 29)
Caltha	*palustris* L.	cowslip, marsh marigold, meadow bright	*Ranunculaceae*	*A. fragariae*	(72)
Calystegia	*sepium* (L.) R. Br.	bindweed, wild morning glory, hedge bindweed	*Convolvulaceae*	*A. ritzemabosi*	(29)
Campanula	*pyramidalis* L.	chimney bellflower	*Campanulaceae*	*A. ritzemabosi*	(33)
Campanula	*raddeana* Trautv.		*Campanulaceae*	*A. fragariae*	(33)
Campanula	*rapunculoides* L.	creeping bellflower, roving bellflower, European bellflower	*Campanulaceae*	*A. ritzemabosi, A. fragariae*	(29, 33)
Capsella	*bursa-pastoris* (L.) Medik.	shepherd's purse	*Brassicaceae*	*A. ritzemabosi*	(18)
Centaurea	*jacea* L.	brown knapweed	*Asteraceae*	*A. ritzemabosi*	(18)
Centaurea	*montana* L.	mountain knapweed, mountain bluet, perennial cornflower	*Asteraceae*	*A. ritzemabosi*	(18)
Cerastium	*fontanum* Baumg. subsp. *vulgare* (Hartm.) Greuter & Burdet	mouse ear chickweed	*Caryophyllaceae*	*A. ritzemabosi*	(18)
Ceratophyllum	*demersum* L.	hornwort, coontail	*Ceratophyllaceae*	*A. fragariae*	(12), (50)
Ceropteris	*calomelanos* (L.) Underw.			*A. fragariae*	(18)

Table 1. Continued

Ceratostigma	*willmottianum* Stapf	Chinese plumbago	*Plumbaginaceae*	*A. ritzemabosi*	(29)
Cheilanthes	*alabemensis* (Buckl.) Kunze	Alabama lip fern	*Pteridaceae*	*A. fragariae*	(42)
Cheilanthes	*argentea* (S. G. Gmelin) Kunze	lip fern	*Pteridaceae*	*A. fragariae*	(42)
Cheilanthes	*lanosa* (Michx.) D. C. Eaton	hairy lip fern	*Pteridaceae*	*A. fragariae*	(42)
Cheilanthes	*wrightii* Hook.	Wright's lip fern	*Pteridaceae*	*A. fragariae*	(42)
Cheiranthus	*spp.*	wall-flower	*Brassicaceae*	*A. ritzemabosi*	(29)
Chelidonium	*majus* L.	celandine, swallowwort	*Papaveraceae*	*A. ritzemabosi*	(18)
Chelone	*lyonii* Pursh	turtlehead	*Scrophulariaceae*	*A. ritzemabosi*	(29)
Chenopodium	*album* L.	lamb's quarters, white goosefoot, fat hen	*Chenopodiaceae*	*A. ritzemabosi*	(18)
Chloranthus	*spicatus* (Thunb.) Makino	chulantree	*Chloranthaceae*	*A. fragariae*	(76)
Chlorophytum	*capense* (L.) Voss		*Liliaceae*	*A. fragariae*	(33)
Chrysanthemum	*hortorum* W. Mill.	garden chrysanthemum	*Asteraceae*	*Aphelenchoides*	(5, 29)
Chrysanthemum	*indicum* L.		*Asteraceae*	*A. ritzemabosi, A. fragariae*	(5, 29)
Chrysanthemum	×*morifolium* Ramat.	chrysanthemum, mum, florist's chrysanthemum	*Asteraceae*	*A. besseyi, A. ritzemabosi*	(18)
Chrysanthemum	*spp.*		*Asteraceae*	*A. besseyi*	(40)
Chrysanthemum	*spp.*		*Asteraceae*	*A. ritzemabosi, A. fragariae*	(12)
Chrysanthemum	*zawadskii* Herbich subsp. *latilobum* (Maxim.) Kitag.		*Asteraceae*	*A. ritzemabosi*	(18)
Chrysogonum	*virginianum* L.	green and gold	*Asteraceae*	*A. fragariae*	(72)
Cibotium	*spp.*		*Dicksoniaceae*	*A. besseyi*	(12)

Table 1. Continued

Cirsium	*arvense* (L.) Scop.	California thistle, creeping thistle, Canadian thistle	*Asteraceae*	*A. ritzemabosi*	(18)
Clematis	*alpina* (L.) Mill.		*Ranunculaceae*	*A. fragariae, A ritzemabosi*	(5, 29)
Clematis	*heracleifolia* DC.	hyacinth-flower clematis	*Ranunculaceae*	*A. fragariae*	(18)
Clematis	*tangutica* (Maxim.) Korsh.		*Ranunculaceae*	*A. ritzemabosi*	(18)
Clematis	*vitalba* L.	old man's beard, traveler's joy	*Ranunculaceae*	*A. ritzemabosi, A. fragariae*	(18)
Cochlearia	*officinalis* L.	scurvy grass, spoonwort	*Brassicaceae*	*A. ritzemabosi*	(18)
Colchicum	*spp.*		*Liliaceae*	*A. ritzemabosi, A. fragariae*	(18, 29)
Coniogramme	*japonica* (Thunb.) Diels		*Pteridaceae*	*A. fragariae*	(5)
Convallaria	*majalis* L.	lily-of-the-valley	*Liliaceae*	*A. fragariae*	(5)
Convolvulus	*arvensis* L.	field bindweed	*Convolvulaceae*	*A. fragariae*	(33)
Cornus	*canadensis* L.	creeping dogwood, dwarf cornel, bunchberry	*Cornaceae*	*A. fragariae*	(72)
Cornus	*florida* L.	flowering dogwood, eastern flowering dogwood	*Cornaceae*	*A. fragariae*	(9)
Crassula	*coccinea* L.		*Crassulaceae*	*A. ritzemabosi*	(29)
Crassula	*spp.*		*Crassulaceae*	*A. fragariae*	(5)
Crossandra	*infundibuliformis* (L.) Nees	firecracker plant, firecracker flower, shamrock	*Acanthaceae*	*A. fragariae*	(18)
Cryptophragmium	*zeylanicum*		*Acanthaceae*	*A. fragariae*	(5)
Cyathea	*cooperi* (Hook. ex F. Muell.) Domin	Australian tree fern, straw tree fern	*Cyatheaceae*	*A. fragariae*	(61)
Cyclamen	*persicum Mill.*	florist's cyclamen	*Primulaceae*	*A. ritzemabosi, A. fragariae*	(18)
Cyclamen	*spp.*		*Primulaceae*	*A. fragariae*	(18)

Table 1. Continued

Cymbidium	*spp.*		*Orchidaceae*	*A. fragariae*	(33)
Cyperus	*alternifolius L.*		*Cyperaceae*	*A. fragariae*	(5)
Cyperus	*iria L.*	grasshopper's cyperus, rice flat sedge, umbrella sedge	*Cyperaceae*	*A. besseyi*	(18)
Cypripedium	*spp.*		*Orchidaceae*	*A. fragariae*	(5)
Cystopteris	*bulbifera (L.) Bernh.*	bulblet bladder fern	*Dryopteridaceae*	*A. fragariae*	(5)
Cystopteris	*fragilis* (L.) Bernh.	brittle fern, fragile fern, brittle bladderfern	*Dryopteridaceae*	*A. fragariae*	(5)
Dahlia	*pinnata* Cav.		*Asteraceae*	*A. besseyi, A. fragariae, A. ritzemabosi*	(18)
Dahlia	*spp.*		*Asteraceae*	*A. ritzemabosi, A. fragariae*	(18)
Davallia	*canariensis* (L.) Sm.	deer-foot fern	*Davalliaceae*	*A. fragariae*	(33)
Davallia	*denticulata* (Burm. f.) Mett. ex Kuhn		*Davalliaceae*	*A. fragariae*	(5)
Davallia	*solida* (Forst.) Sw.	sturdy davallia	*Davalliaceae*	*A. fragariae*	(5)
Davallia	*trichomanoides* Blume	squirrel's foot fern	*Davalliaceae*	*A. fragariae*	(12)
Delphinium	*spp.*		*Ranunculaceae*	*A. ritzemabosi*	(5, 29)
Dianella	*revolutum*		*Liliaceae*	*A. fragariae*	(33)
Dianthus	*caryophyllus* L.	carnation, clove pink, border carnation	*Caryophyllaceae*	*Aphelenchoides*	(5, 29)
Diervilla	*spp.*		*Caprifoliaceae*	*A. ritzemabosi*	(18)
Digitalis	*grandiflora* Mill.	yellow foxglove, large yellow foxglove	*Scrophulariaceae*	*A. ritzemabosi*	(29)
Digitalis	*purpurea* L.	foxglove	*Scrophulariaceae*	*A. ritzemabosi, A. fragariae*	(18, 33)

Table 1. Continued

Digitalis	*sanguinalis*		*Scrophulariaceae*	*A. besseyi*	(18)
Digitalis	*spp.*		*Scrophulariaceae*	*A. fragariae*	(42)
Dioscorea	*trifida* L. f.	cush-cush, cush-cush yam, mapuey	*Dioscoreaceae*	*A. besseyi*	(30)
Diphylleia	*cymosa* Michx.	umbrella leaf	*Berberidaceae*	*A. fragariae*	(72)
Diplazium	*arboreum* (Desr.) Alston		*Dryopteridaceae*	*A. fragariae*	(5)
Diplazium	*cristatum* (Desr.) Alston	crested twinsorus fern	*Dryopteridaceae*	*A. fragariae*	(18)
Diplazium	*dameriae* Pic. Serm.		*Dryopteridaceae*	*A. fragariae*	(18)
Diplazium	*esculentum* (Retz.) Sw.		*Dryopteridaceae*	*A. fragariae*	(43)
Diplazium	*expansum* Willd.		*Dryopteridaceae*	*A. fragariae*	(18)
Diplazium	*proliferum* (Lam.) Thouars		*Dryopteridaceae*	*A. fragariae*	(5)
Diplazium	*pycnocarpon* (Spreng.) Broun	glade fern	*Dryopteridaceae*	*A. fragariae*	(42)
Disporum	*lanuginosum* (Michx.) G. Nicholson	yellow mandarin	*Liliaceae*	*A. fragariae*	(72)
Doronicum	*columnae* Ten.	Eastern leopard's bane	*Asteraceae*	*A. ritzemabosi*	(5, 29)
Doronicum	*orientale* Hoffm.		*Asteraceae*	*A. ritzemabosi, A. fragariae*	(5, 18)
Doronicum	*plantagineum* L.		*Asteraceae*	*A. fragariae*	(5)
Doronicum	*spp.*		*Asteraceae*	*A. ritzemabosi*	(5, 29)
Dryopteris	*affinis* (Lowe) Fraser-Jenk.	golden-scale male fern, scaly male fern	*Dryopteridaceae*	*A. fragariae*	(42)
Dryopteris	*affinis* (Lowe) Fraser-Jenk. subsp. *borreri* (Newman) Fraser-Jenk.	Borrer's scaly male fern	*Dryopteridaceae*	*A. fragariae*	(18)

Table 1. Continued

Dryopteris	*atrata* (Wall. ex Kunze) Ching	shaggy shield fern, black wood fern	*Dryopteridaceae*	*A. fragariae*	(42)
Dryopteris	*boottii* (Tuckerm.) Underw.	Boot's wood fern	*Dryopteridaceae*	*A. fragariae*	(18)
Dryopteris	*carthusiana* (Vill.) H. P. Fuchs	narror buckler fern, spinulose wood fern, toothed wood fern	*Dryopteridaceae*	*A. fragariae*	(18)
Dryopteris	*celsa* (W. Palmer) Knowlt. et al.	log fern	*Dryopteridaceae*	*A. fragariae*	(42)
Dryopteris	*cycadina* (Franch. & Sav.) C. Chr.	blackwood fern, shaggy wood fern	*Dryopteridaceae*	*A. fragariae*	(42)
Dryopteris	*dilatata* (Hoffm.) A. Gray	broad buckler fern, broad wood fern, mountain wood fern	*Dryopteridaceae*	*A. fragariae*	(42)
Dryopteris	*erythrosora* (D. C. Eaton) Kuntze	autumn fern, Japanese shield fern	*Dryopteridaceae*	*A. fragariae*	(42)
Dryopteris	*filix-mas* (L.) Schott	male fern	*Dryopteridaceae*	*A. fragariae*	(18)
Dryopteris	*fuscipes* C. Chr.		*Dryopteridaceae*	*A. fragariae*	(42)
Dryopteris	*goldieana* (Hook. ex Goldie) A. Gray	Goldie's fern, Goldie's wood fern	*Dryopteridaceae*	*A. fragariae*	(42)
Dryopteris	*hirtipes* (Blume) Kuntze		*Dryopteridaceae*	*A. fragariae*	(18)
Dryopteris	*lorentzii* (Hieron.) C. Christ	wood fern	*Dryopteridaceae*	*A. fragariae*	(42)
Dryopteris	*marginalis* (L.) A. Gray	marginal fern, marginal wood fern	*Dryopteridaceae*	*A. fragariae*	(42)
Dryopteris	*remota* (A. Braun ex Döll) Druce	scaly buckler fern	*Dryopteridaceae*	*A. fragariae*	(18)
Dryopteris	*spp.*		*Dryopteridaceae*	*A. fragariae*	(5)
Echinacea	*purpurea* (L.) Moench	Eastern purple coneflower, purple coneflower	*Asteraceae*	*A. fragariae, A ritzemabosi*	(18)
Echium	*spp.*		*Boraginaceae*	*A. ritzemabosi*	(29)
Elingamita	*spp.*		*Myrsinaceae*	*A. ritzemabosi*	(33)
Elsholtzi	*ciliata* (Thunb.) Hyl.	crested late summer mint	*Lamiaceae*	*A. ritzemabosi*	(5, 29)

Table 1. Continued

Epilobium	*montanum* L.		*Onagraceae*	*A. ritzemabosi*	(18)
Epipactis	*palustris* (L.) Crantz	marsh orchid	*Orchidaceae*	*A. fragariae*	(18)
Epiphyllum	*spp.*		*Cactaceae*	*A. ritzemabosi*	(33)
Epipremnum	*pinnatum* (L.) Engl.	golden pothos, Tongavine, variegated philodendron	*Araceae*	*A. ritzemabosi, A. fragariae*	(18)
Episcia	*lilacina* Hanst.	flame violet	*Gesneriaceae*	*A. fragariae*	(5)
Erechtites	*praealta* Raf.		*Asteraceae*	*A. besseyi*	(18)
Eremurus	*stenophyllus* (Boiss. & Buhse) Baker		*Asphodelaceae*	*A. ritzemabosi*	(29)
Erigeron	*albidus* (Willd. ex Spreng.) A.Gray		*Asteraceae*	*A. ritzemabosi*	(18)
Erigeron	*atticus* Vill.		*Asteraceae*	*A. ritzemabosi*	(18)
Erigeron	*glabellus* Nutt.	streamside fleabane	*Asteraceae*	*A. ritzemabosi*	(18)
Erigeron	*hybridus* Bergmans		*Asteraceae*	*A. ritzemabosi*	(29)
Erigeron	*uniflorus* L.		*Asteraceae*	*A. ritzemabosi*	(18)
Eryngium	*alpinum* L.		*Apiaceae*	*A. fragariae*	(5)
Erysimum	*perofskianum* Fisch. & C. A. Mey.		*Brassicaceae*	*A. ritzemabosi*	(29)
Fatsia	*japonica* (Thunb.) Decne. & Planch.	fatsi, glossyleaf paperplant, Japanese fatsia	*Araliaceae*	*A. fragariae*	(33)
Fatsia	*spp.*		*Araliaceae*	*A. ritzemabosi*	(12)
Ficus	*benjamina* L.	benjamin tree, Java fig, weeping fig	*Moraceae*	*A. fragariae*	(12)
Ficus	*benjamina* L. var. *comosa* (Roxb.) Kurz		*Moraceae*	*Aphelenchoides*	(5)
Ficus	*elastica* Roxb. ex Hornem.	India rubber fig, Indian rubber tree, rubber tree	*Moraceae*	*A. besseyi, A. fragariae*	(18, 40)
Ficus	*macrophylla* Desf. ex Pers.	Moreton Bay fig	*Moraceae*	*A. fragariae*	(47)

Table 1. Continued

Ficus	*pumila* L.		*Moraceae*	*A. fragariae*	(5)
Ficus	*sagittata* Vahl	trailing fig	*Moraceae*	*A. fragariae*	(5)
Forsythia	*suspensa* (Thunb.) Vahl	forsythia, goldenbells, weeping forsythia	*Oleaceae*	*A. ritzemabosi*	(18)
Fragaria	*chiloensis* (L.) Mill.	beach strawberry, Chilean strawberry	*Rosaceae*	*A. fragariae*	(12)
Fragaria	*spp.*		*Rosaceae*	*A. besseyi*	(39)
Fragaria	*spp.*		*Rosaceae*	*A. ritzemabosi and A. fragariae*	(33)
Fragaria	*vesca* L.	European strawberry, wild strawberry, woodland strawberry	*Rosaceae*	*A. ritzemabosi*	(18)
Fragaria	×*ananassa* Duchesne ex Rozier	garden strawberry, strawberry	*Rosaceae*	*A. besseyi, A. fragariae, A. ritzemabosi*	(18)
Fuchsia	*spp.*		*Onagraceae*	*A. fragariae*	(5)
Gaillardia	×*grandiflora* hort. ex Van Houtte		*Asteraceae*	*A. ritzemabosi*	(18)
Galium	*aparine* L.	catchweed bedstraw, cleavers, goose grass	*Rubiaceae*	*A. ritzemabosi*	(18)
Gardenia	*jasminoides* J. Ellis	Cape jessamine, jasmin	*Rubiaceae*	*A. fragariae*	(18)
Geranium	*macrorrhizum* L.	bigroot geranium, Bulgarian geranium, rock crane's-bill	*Geraniaceae*	*A. fragariae*	(18)
Geranium	*maculatum* L.	spotted geranium, wild geranium	*Geraniaceae*	*A. fragariae*	(72)
Geranium	*maderense* Yeo		*Geraniaceae*	*A. fragariae*	(33)
Geranium	*subcaulescens* L'Hér. ex DC.		*Geraniaceae*	*A. fragariae*	(18)
Gerbera	*jamesoni* Bolus ex Hooker f.		*Asteraceae*	*A. fragariae*	(18)
Glandularia	*tenera* (Spreng.) Cabrera		*Verbenaceae*	*A. fragariae*	(18)
Glechoma	*hederacea* L.		*Lamiaceae*	*A. fragariae, A ritzemabosi*	(18)

Table 1. Continued

Gloxinia	*nematanthodes* (O.Kuntze) Wiehler		*Geraniaceae*	*A. fragariae*	(42)
Gloxinia	*spp.*		*Gesneriaceae*	*A. ritzemabosi*	(29)
Gomphrena	*globosa* L.	bachelor's button, common globe amaranth	*Amaranthaceae*	*A. fragariae*	(18)
Goniolimon	*speciosum* (L.) Boiss.		*Plumbaginaceae*	*A. ritzemabosi*	(18)
Gunnera	*spp.*		*Gunneraceae*	*A. fragariae*	(33)
Gunnera	*tinctoria* (Molina) Mirb.		*Grossulariaceae*	*A. fragariae*	(18)
Gymnostachyum	*ceylanicum*		*Pteridaceae*	*A. fragariae*	(18)
Gypsophila	*cerastoides* D. Don		*Caryophyllaceae*	*A. fragariae*	(18)
Helenium	*autumnale* L.	common sneezeweed	*Asteraceae*	*A. ritzemabosi*	(18)
Helianthus	*annuus* L.	sunflower	*Asteraceae*	*A. ritzemabosi*	(18)
Helianthus	*decapetalus* L.	ten petals sunflower, thin leaf sunflower	*Asteraceae*	*A. ritzemabosi*	(18)
Helianthus	*spp.*		*Asteraceae*	*A. ritzemabosi*	(33)
Helianthus	*tuberosus* L.	Jerusalem artichoke	*Asteraceae*	*A. ritzemabosi*	(18)
Helichrysum	*spp.*		*Asteraceae*	*A. fragariae*	(5)
Heliopsis	*helianthoides* (L.) Sweet	false sunflower, oxeye	*Asteraceae*	*A. fragariae*	(42)
Heliopsis	*helianthoides* (L.) Sweet var. *scabra* (Dunal) Fernald		*Asteraceae*	*A. ritzemabosi*	(18)
Helleborus	*antiquorum* A. Braun	ancient hellebore	*Ranunculaceae*	*A. fragariae*	(18)
Helleborus	*cyclophyllus* Boissier		*Ranunculaceae*	*A. fragariae*	(18)
Helleborus	*foetidus* L.	stinking hellebore	*Ranunculaceae*	*A. fragariae*	(5)
Helleborus	*intermedius* Host.		*Ranunculaceae*	*A. fragariae*	(18)
Helleborus	*niger* L.	black helleborus, Christmas rose	*Ranunculaceae*	*A. ritzemabosi, A. fragariae*	(18, 33)

Table 1. Continued

Helleborus	*olympicus* Lindl.		*Ranunculaceae*	*A. fragariae*	(18)
Helleborus	*orientalis* Lam.	lenten rose	*Ranunculaceae*	*A. fragariae*	(18)
Helleborus	*orientalis* Lam. ssp. *abchasicus* (A. Braun) B.Mathew		*Ranunculaceae*	*A. fragariae*	(18)
Hemerocallis	*spp.*		*Liliaceae*	*A. ritzemabosi*	(33)
Hemigraphis	*colorata* (Blume) H. G. Hallier	broad leaf hemigraphis	*Acanthaceae*	*A. fragariae*	(5)
Hepatica	*acutiloba* (DC.) G. Lawson	sharp-lobed hepatica, sharp-lobed liverleaf	*Ranunculaceae*	*A. fragariae*	(72)
Heuchera	*sanguinea* Engelm.	coral bells	*Saxifragaceae*	*A. ritzemabosi, A. fragariae*	(5, 29)
Hibiscus	*rosa-sinensis* L.	Chinese hibiscus, Hawaiian hibiscus, rose of China	*Malvaceae*	*A. fragariae*	(33)
Horminum	*pyrenaicum* L.	dragon mouth, Pyrenean dead nettle	*Lamiaceae*	*A. fragariae*	(5)
Hortensia	*spp.*		*Hydrangeaceae*	*A. ritzemabosi*	(29)
Hosta	*spp.*		*Liliaceae*	*A. fragariae*	(46)
Hyacinthoides	*hispanica* (Mill.) Rothm.		*Hyacinthaceae*	*A. fragariae*	(5)
Hydrangea	*macrophylla*		*Hydrangeaceae*	*A. besseyi*	(18)
Hydrangea	*macrophylla*		*Hydrangeaceae*	*A. fragariae*	(10)
Hydrangea	*macrophylla* (Thunb.) Ser. subsp. *macrophylla*	hortensia, lacecap hydrangea	*Hydrangeaceae*	*A. fragariae*	(5)
Hydrilla	*verticillata* (L. f.) Royle	Florida elodea, Indian stargrass, water thyme	*Hydrocharitaceae*	*A. fragariae*	(12)
Hydrophyllum	*canadense* L.		*Hydrophyllaceae*	*A. fragariae*	(18)
Hydrophyllum	*virginianum* L.	John's cabbage, Virginia waterleaf	*Hydrophyllaceae*	*A. fragariae*	(72)
Hylotelephium	*telephioides* (Michx.) H. Ohba	Allegheny stonecrop	*Crassulaceae*	*A. ritzemabosi*	(29)

Table 1. Continued

Hylotelephium	*telephium* (L.) H. Ohba subsp. *maximum* (L.) H. Ohba	witch's moneybags	*Crassulaceae*	*A. ritzemabosi*	(18)
Hymenoxys	*hoopesii* (A. Gray) Bierner		*Asteraceae*	*A. ritzemabosi*	(29)
Impatiens	*balfourii* Hook. f.		*Balsaminaceae*	*A. ritzemabosi*	(18)
Impatiens	*balsamina* L.	garden balsam, rose balsam, touch-me-not	*Balsaminaceae*	*A. besseyi, A. fragariae*	(18)
Incarvillea	*delavayi* Bureau & Franch.		*Bignoniaceae*	*A. ritzemabosi*	(5, 29)
Ipomoea	*alba* L.	moonflower	*Convolvulaceae*	*Aphelenchoides*	(5)
Ipomoea	*purpurea* (L.) Roth	common morning glory, tall morning glory	*Convolvulaceae*	*A. ritzemabosi*	(29)
Iris	*ensata* Thunb.	Japanese iris, Japanese water iris, sword leaf iris	*Iridaceae*	*A. fragariae*	(42)
Iris	*spp.*		*Iridaceae*	*A. ritzemabosi, A. fragariae*	(5), (33)
Isatis	*tinctoria* L.	dyer's woad, woad	*Brassicaceae*	*A. ritzemabosi*	(18)
Jasminum	*simplicifolium* G.Forst.	wax jasmine, Australian wax jasmine	*Oleaceae*	*A. besseyi*	(61)
Jasminum	*spp.*		*Oleaceae*	*A. besseyi*	(12)
Jeffersonia	*dubia* (Maxim.) Benth. & Hook. f. ex Baker & S. Moore	twin leaf	*Berberidaceae*	*A. fragariae*	(72)
Jovellana	*sinclairii* (Hook.) Kraenzl.		*Calceolariaceae*	*A. ritzemabosi*	(29, 33)
Kalanchoe	*coccinea* Welw. ex Britten		*Crassulaceae*	*A. fragariae*	(18)
Knautia	*arvensis* (L.) Coult.	bluebuttons, field scabious, gypsy's rose	*Dipsacaceae*	*A. ritzemabosi, A. fragariae*	(18)
Knautia	*macedonica* Griseb.	crimson scabious	*Dipsacaceae*	*A. fragariae*	(18)

Table 1. Continued

Lactuca	*sativa* L.	garden lettuce, lettuce	*Asteraceae*	*A. ritzemabosi*	(5, 29)
Lamium	*album* L.	white dead-nettle, white nettle	*Lamiaceae*	*A. ritzemabosi, A. fragariae*	(5, 29)
Lamium	*galeobdolon* L.	yellow archangel	*Lamiaceae*	*A. fragariae*	(42)
Lamium	*maculatum* L.	spotted dead-nettle	*Lamiaceae*	*A. ritzemabosi, A. fragariae*	(29, 35)
Lamium	*purpureum* L.	purple dead-nettle, red archangel, red dead-nettle	*Lamiaceae*	*A. ritzemabosi*	(18, 33)
Lantana	*camara* L.	lantana	*Verbenaceae*	*A. fragariae*	(42)
Lantana	*spp.*	lantana, wild sage	*Verbenaceae*	*A. fragariae*	(5, 33)
Lapageria	*rosea* Ruiz & Pav.	Chilean bellflower	*Philesiaceae*	*A. fragariae*	(33)
Lavandula	*angustifolia* Mill. subsp. *angustifolia*		*Lamiaceae*	*A. ritzemabosi*	(18)
Lavandula	*dentata* L.	French lavender	*Lamiaceae*	*A. fragariae*	(33)
Lemna	*spp.*		*Lemnaceae*	*A. besseyi, A. fragariae*	(12)
Leucanthemum	*maximum* Ramond		*Asteraceae*	*A. besseyi, A. ritzemabosi*	(18), (6)
Leucanthemum	*vulgare* Lam.	moon daisy, oxeye daisy, margriet	*Asteraceae*	*A. ritzemabosi, A. fragariae*	(18)
Lewisia	*spp.*		*Portulacaceae*	*A. ritzemabosi*	(29)
Ligularia	*stenocephala* (Maxim.) Matsum. & Koidz.	ligularia	*Asteraceae*	*Aphelenchoides*	(73)
Ligustrum	*vulgare* L.	common privet, European privet, privet	*Oleaceae*	*A. fragariae*	(5)

Table 1. Continued

Lilium	*canadense* L.	Canada lily, wild meadow lily, yellow bell lily	*Liliaceae*	*A. fragariae*	(72)
Lilium	*henryi* Baker	Henry's lily	*Liliaceae*	*A. ritzemabosi, A. fragariae*	(18)
Lilium	*humboldtii* Roezl & Leichtlin ex Duch.	Humboldt lily	*Liliaceae*	*A. fragariae*	(18)
Lilium	*humboldtii x pardalinum*		*Liliaceae*	*A. fragariae*	(18)
Lilium	*lancifolium* Thunb.	tiger lily, devil lily, Easter lily	*Liliaceae*	*A. ritzemabosi, A. fragariae*	(33)
Lilium	*longiflorum* Thunb.	Easter lily, trumpet lily	*Liliaceae*	*A. fragariae*	(18)
Lilium	*pardalinum* Kellogg subsp. *pardalinum*	leopard lily	*Liliaceae*	*A. fragariae*	(18)
Lilium	*philippinense* Baker	Philippine lily	*Liliaceae*	*A. fragariae*	(5)
Lilium	*pumilum* DC.	coral lily	*Liliaceae*	*A. ritzemabosi, A. fragariae*	(18)
Lilium	*regale* E. H. Wilson	regal lily, royal lily	*Liliaceae*	*A. ritzemabosi, A. fragariae*	(18, 33)
Lilium	*sargentiae* E. H. Wilson	Sargent lily	*Liliaceae*	*A. fragariae*	(18)
Lilium	*speciosum* Thunb.	Japanese lily, showy lily, speciosum lily	*Liliaceae*	*A. fragariae*	(18)
Lilium	*sulphurgale*		*Liliaceae*	*A. fragariae*	(18)
Lilium	*umbellatum* Pursh	umbel lily	*Liliaceae*	*A. fragariae*	(18)
Limnobium	*spongia* (Bosc) Steud.	American spongeplant, frog's bit	*Hydrocharitaceae*	*A. fragariae*	(12)
Limnophila	*spp.*		*Scrophulariaceae*	*A. fragariae*	(55)
Limonium	*bellidifolium* (Gouan) Dumort.		*Plumbaginaceae*	*A. ritzemabosi*	(29)
Limonium	*gerberi* Soldano		*Plumbaginaceae*	*A. ritzemabosi, A. fragariae*	(5, 29, 33)
Limonium	*sinuatum* (L.) Mill.	perennial sea-lavender	*Plumbaginaceae*	*A. fragariae*	(18)

Table 1. Continued

Limonium	*vulgare* Mill.		*Plumbaginaceae*	*A. ritzemabosi*	(18)
Liriope	*muscari* (Decne.) L. H. Bailey		*Liliaceae*	*A. fragariae*	(33)
Liriope	*spicata* (Thunb.) Lour.	creeping liriope	*Liliaceae*	*A. fragariae*	(33)
Lithodora	*diffusa* (Lag.) I. M. Johnst.	scrambling gromwell, shrubby gromwell	*Boraginaceae*	*A. fragariae*	(33)
Lobelia	*erinus* L.		*Campanulaceae*	*A. fragariae*	(18)
Lophostemon	*confertus* (R. Br.) Peter G. Wilson & J. T. Waterh.	brush box, redbox, vinegar tree	*Myrtaceae*	*A. ritzemabosi*	(33)
Lotus	*corniculatus* L.	bird's-foot trefoil	*Fabaceae*	*A. ritzemabosi*	(33)
Lupinus	*spp.*		*Fabaceae*	*A. ritzemabosi*	(18)
Lycopersicon	*esculentum* Mill.	tomato	*Solanaceae*	*A. ritzemabosi*	(18, 33)
Lycopodium	*clavatum* L.	club moss, elk moss, ground-pine	*Lycopodiaceae*	*A. besseyi*	(12)
Lycoris	*radiata* (L'Hér.) Herbert		*Liliaceae*	*A. fragariae*	(18)
Lygodium	*circinatum* (Burm.f.) Sw.		*Schizaeaceae*	*A. besseyi, A. fragariae*	(12, 18)
Lygodium	*volubile* Sw.		*Schizaeaceae*	*A. fragariae*	(5)
Macropiper	*excelsum* (G. Forst.) Miq. subsp. *psittacorum* (Endl.) Sykes		*Piperaceae*	*A. fragariae*	(33)
Maianthemum	*racemosum* (L.) Link	large false Solomon's seal, Solomon's plume, treacle-berry	*Ruscaceae*	*A. fragariae*	(72)
Maranta	*leuconeura* E. Morren	prayerplant, ten commandments	*Marantaceae*	*A. fragariae*	(51)
Marattia	*salicifolia* Schrad.	king fern	*Marattiaceae*	*A. ritzemabosi*	(33)
Marattia	*salicina* Sm.in Rees	king fern, potato fern	*Marattiaceae*	*A. fragariae*	(33)

Table 1. Continued

Marchantia	*spp.*		*Marchantiaceae*	*A. fragariae*	(33)
Marshallia	*caespitosa* Nutt. ex DC.		*Asteraceae*	*A. fragariae*	(42)
Matricaria	*grandiflora* (Hook.) Britt.		*Asteraceae*	*A. ritzemabosi*	(31)
Matteuccia	*orientalis* (Hook.) Trevis.		*Dryopteridaceae*	*A. ritzemabosi*	(18)
Medicago	*polymorpha* L.	bur medic, hairy medic, toothed bur-clover	*Fabaceae*	*A. ritzemabosi*	(33)
Medicago	*sativa* L.		*Fabaceae*	*A. fragariae*	(12)
Medicago	*sativa* L.		*Fabaceae*	*A. ritzemabosi*	(18, 33)
Mentha	×*piperita* L.	peppermint	*Lamiaceae*	*A. ritzemabosi*	(18)
Mentha	*spicata* L.	spearmint	*Lamiaceae*	*A. fragariae*	(18)
Mertensia	*sibirica* (L.) G. Don		*Boraginaceae*	*A. ritzemabosi*	(29)
Microlepia	*platyphylla* (Don) J. Sm.	plate fern	*Dennstaedtiaceae*	*A. fragariae*	(5)
Mildella	*nitidula* (Wall. ex Hook.) Hall et Lell.		*Pteridaceae*	*A. fragariae*	(42)
Mimulus	*guttatus* DC.	common monkey-flower	*Scrophulariaceae*	*A. ritzemabosi*	(18)
Morina	*longifolia* Wall. ex DC.		*Morinaceae*	*A. ritzemabosi*	(18)
Musa	*uranoscopos* Lour.		*Musaceae*	*A. fragariae*	(33)
Muscari	*spp.*		*Liliaceae*	*A. ritzemabosi*	(29)
Myriophyllum	*spicatum* L.	Eurasian water-milfoil, spike water-milfoil	*Haloragaceae*	*A. fragariae*	(12)
Najas	*flexilis* (Willd.) Rostk. & W. L. E. Schmidt	slender naiad	*Najadaceae*	*A. fragariae*	(12)
Narcissus	*pseudonarcissus* L.	common daffodil, trumpet narcissus	*Liliaceae*	*A. fragariae*	(18)
Narcissus	*spp.*		*Liliaceae*	*A. fragariae*	(12)
Nemesia	*reptans*		*Scrophulariaceae*	*A. ritzemabosi*	(33)

Table 1. Continued

Nepeta	*hederacea* (L.) Trev	ground ivy	*Lamiaceae*	*A. fragariae*	(5)
Nephrolepis	*biserrata* (Sw.) Schott	giant sword fern	*Dryopteridaceae*	*A. fragariae*	(18)
Nephrolepis	*exaltata* (L.) Schott	Boston sword fern	*Dryopteridaceae*	*A. fragariae*	(5)
Nerine	*spp.*		*Liliaceae*	*A. fragariae*	(5)
Nicotiana	*alata* Link & Otto	jasmine tobacco	*Solanaceae*	*A. ritzemabosi*	(18)
Nicotiana	*rustica* L.	native tobacco, wild tobacco, Aztec tobacco	*Solanaceae*	*A. ritzemabosi*	(18)
Nicotiana	*spp.*		*Solanaceae*	*A. fragariae*	(18)
Nicotiana	*tabacum* L.	tobacco	*Solanaceae*	*A. ritzemabosi*	(18)
Nicotiana	*virginiana*		*Solanaceae*	*A. ritzemabosi, A. fragariae*	(18)
Ocimum	*basilicum* L.	basil, sweet basil	*Lamiaceae*	*A. ritzemabosi*	(33)
Ocimum	*spp.*		*Lamiaceae*	*A. ritzemabosi*	(5)
Ocymum	*spp.*		*Lamiaceae*	*A. ritzemabosi*	(29)
Odontoglossum	*spp.*		*Orchidaceae*	*A. fragariae*	(18)
Omphalodes	*verna* Moench	creeping forget-me-not, blue-eyed Mary	*Boraginaceae*	*A. fragariae*	(5)
Orchidaceae	*spp.*		*Orchidaceae*	*A. ritzemabosi, A. fragariae*	(12)
Oryza	*sativa* L.	rice, lowland rice, upland rice	*Poaceae*	*A. besseyi*	(18)
Osmunda	*japonica* Thunb.		*Osmundaceae*	*A. fragariae*	(42)
Osmunda	*regalis* L.	royal fern	*Osmundaceae*	*A. fragariae*	(5)
Oxalis	*regnellii*		*Oxalidaceae*	*A. fragariae*	(42)
Paeonia	*lactiflora* Pall.	Chinese peony, common garden peony	*Paeoniaceae*	*A. fragariae*	(18)
Paeonia	*lutea* Delavay ex Franch.		*Paeoniaceae*	*A. fragariae*	(18)
Paeonia	*mlokosewitschii* Lomakin		*Paeoniaceae*	*A. fragariae*	(56)

Table 1. Continued

Paeonia	*officinalis* L.	common peony, cottage peony, European peony	*Paeoniaceae*	*A. fragariae*	(18)
Paeonia	*spp.*		*Paeoniaceae*	*A. ritzemabosi, A. fragariae*	(5, 29)
Paeonia	*suffruticosa* Andrews	moutan peony, tree peony	*Paeoniaceae*	*A. fragariae*	(18)
Paeonia	*wittmanniana* Lindl.		*Paeoniaceae*	*A. fragariae*	(18)
Papaver	*orientale* L.	Oriental poppy	*Papaveraceae*	*A. ritzemabosi*	(18)
Paphiopedilum	*dayanum (Lindl.) Stein*		*Orchidaceae*	*A. fragariae*	(18)
Paphiopedilum	*spp.*		*Orchidaceae*	*A. fragariae*	(18)
Paris	*quadrifolia* L.	herb-Paris	*Melanthiaceae*	*A. fragariae*	(2)
Passiflora	*edulis* Sims	purple granadilla, grenadella	*Passifloraceae*	*A. ritzemabosi*	(33)
Pelargonium	*spp.*		*Geraniaceae*	*A. fragariae*	(5)
Pellaea	*nitidula* (Hook.) Wall. ex Bak.		*Pteridaceae*	*A. fragariae*	(42)
Peltiphyllum	*peltatum* (Torr.) Engl.	umbrella plant, Indian rhubarb	*Saxifragaceae*	*A. ritzemabosi, A. fragariae*	(18)
Penstemon	*barbatus* (Cav.) Roth		*Scrophulariaceae*	*A. ritzemabosi, A. fragariae*	(5, 29)
Penstemon	*gentianoides* (Kunth) Poir.		*Scrophulariaceae*	*A. ritzemabosi, A. fragariae*	(5, 29)
Penstemon	*hirsutus* (L.) Willd.	hairy beardtongue, northeastern beardtongue	*Scrophulariaceae*	*A. ritzemabosi, A. fragariae*	(18)
Penstemon	*laevigatus* Aiton	eastern smooth beardtongue	*Scrophulariaceae*	*A. ritzemabosi*	(18)
Penstemon	*neomexicanus* Woot. & Standl.	New Mexico beardtongue	*Scrophulariaceae*	*A. fragariae*	(18)
Pentas	*lanceolata* (Forssk.) Deflers	Egyptian star-cluster, star-cluster	*Rubiaceae*	*A. fragariae*	(18)
Peperomia	*argyreia* (Miq.) E. Morren	watermelon pepper, watermelon begonia	*Piperaceae*	*A. ritzemabosi*	(12)

Table 1. Continued

Peperomia	*caperata* Yunck.	emerald ripple pepper, green ripple pepper, little fantasy pepper	*Piperaceae*	*A. ritzemabosi*	(18)
Peperomia	*glabella* (Sw.) A. Dietr.		*Piperaceae*	*A. ritzemabosi*	(18)
Peperomia	*griseoargentea* Yunck.	ivy pepper, platinum pepper, silverleaf pepper	*Piperaceae*	*A. ritzemabosi*	(29)
Peperomia	*magnoliaefolia* (Jacq.) A. Dietr.	desert privet	*Piperaceae*	*A. ritzemabosi*	(33)
Peplis	*diandra* Nutt. ex DC.		*Lythraceae*	*A. fragariae*	(55)
Pericallis	*cruenta* (Masson ex L'Hér.) Bolle		*Asteraceae*	*A. ritzemabosi*	(18)
Pericallis	*x hybrida R. Nordenstam*	florist's cineraria, cineraria	*Asteraceae*	*A. ritzemabosi*	(33)
Persicaria	*maculosa* Gray	lady's thumb, redshank, spotted lady's thumb	*Polygonaceae*	*A. fragariae*	(33)
Petunia	*spp.*		*Solanaceae*	*A. ritzemabosi*	(29)
Phaseolus	*vulgaris* L.	bean	*Fabaceae*	*A. ritzemabosi*	(18)
Phegopteris	*decursive-pinnata* (H. C. Hall) Fee	winged beech fern, Japanese beech fern	*Dryopteridaceae*	*A. fragariae*	(18)
Phlebodium	*aureum* (L.) J. Sm.	gold-foot fern, golden polypody, rabbit's foot fern	*Polypodiaceae*	*A. fragariae*	(5)
Phlebodium	*pseudoaureum* (Cav.) Lellinger		*Polypodiaceae*	*A. fragariae*	(18)
Phlox	*amoena* Sims	hairy phlox	*Polemoniaceae*	*A. ritzemabosi*	(18)
Phlox	*decussata* Lyon ex Pursh		*Polemoniaceae*	*A. fragariae*	(5)
Phlox	*douglasii* Hook.		*Polemoniaceae*	*A. ritzemabosi*	(18)
Phlox	*drummondii* Hook.	annual phlox, Drummond's phlox, pride-of-Texas	*Polemoniaceae*	*A. ritzemabosi*	(5, 29)
Phlox	*paniculata* L.	fall phlox, garden phlox, summer phlox	*Polemoniaceae*	*A. ritzemabosi, A. fragariae*	(18)
Phlox	*subulata* L.	moss phlox, moss pink, mountain phlox	*Polemoniaceae*	*A. ritzemabosi*	(18)

Table 1. Continued

Phoenix	*roebelenii* O'Brien	pygmy date palm	*Arecaceae*	*A. fragariae*	(33)
Phyllocactus	*spp.*		*Cactaceae*	*A. fragariae*	(18)
Phymatodes	*diversifolium* (Willd.) Pich.Ser.		*Polypodiaceae*	*A. fragariae*	(33)
Phytolacca	*icosandra* L.	red inkplant, tropical pokeweed	*Phytolaccaceae*	*A. ritzemabosi*	(33)
Pinus	*palustris* Mill.	longleaf pine, pitch pine, southern yellow pine	*Pinaceae*	*A. fragariae*	(5)
Pityrogramma	*calomelanos* (L.) Link	dixie silverback fern, silver fern	*Pteridaceae*	*A. fragariae*	(18)
Pityrogramma	*chrysophylla* (Sw.) Link	island goldback fern	*Pteridaceae*	*A. fragariae*	(60)
Pityrogramma	*triangularis* (Kaulfuss)	goldback fern	*Pteridaceae*	*A. fragariae*	(60)
Plantago	*lanceolata* L.	buckhorn, ribgrass, ribwort plantain	*Plantaginacea*	*A. ritzemabosi*	(33)
Plantago	*major* L.	broadleaf plantain, common plantain, grand plantain	*Plantaginacea*	*A. ritzemabosi*	(18)
Platycerium	*ellisii* Baker	staghorn fern	*Polypodiaceae*	*A. fragariae*	(12)
Pluchea	*odorata* (L.) Cass. var. odorata		*Asteraceae*	*A. besseyi*	(18)
Poa	*annua* L.	annual bluegrass, annual meadow grass	*Poaceae*	*A. ritzemabosi*	(18)
Podophyllum	*peltatum* L.	American mandrake, mayapple	*Berberidaceae*	*A. ritzemabosi*	(18)
Podophyllum	*pleianthum* Hance		*Berberidaceae*	*A. fragariae*	(42)
Polianthes	*tuberosa* L.	tuberose	*Agavaceae*	*A. besseyi*	(3)
Polianthes	*tuberosa* L.	tuberose	*Agavaceae*	*A. ritzemabosi*	(29, 44)
Polypodium	*brasiliense* Poir.	angle-vein fern	*Polypodiaceae*	*A. fragariae*	(5)
Polypodium	*percussum* Cav.		*Polypodiaceae*	*A. fragariae*	(5)
Polypodium	*phymatodes* L.		*Polypodiaceae*	*A. fragariae*	(18)
Polypodium	*punctatum* (L.) Sw.	dwarf elkhorn fern	*Polypodiaceae*	*A. fragariae*	(5)

Table 1. Continued

Polypodium	*repens* Aubl.		*Polypodiaceae*	*A. fragariae*	(5)
Polypodium	*vulgare* L.	golden maidenhair, wall fern, common polypody	*Polypodiaceae*	*A. fragariae*	(18)
Polystichum	*acrostichoides* (Michx.) Schott	Christmas fern, dagger fern	*Dryopteridaceae*	*A. fragariae*	(42)
Polystichum	*braunii* (Spenn.) Fée	Braun's holly fern	*Dryopteridaceae*	*A. fragariae*	(72)
Polystichum	*munitum* (Kaulf.) C. Presl	common sword fern, western sword fern	*Dryopteridaceae*	*A. fragariae*	(18)
Polystichum	*xiphophyllum* (Bak.) Diels.		*Dryopteridaceae*	*A. fragariae*	(42)
Potamogeton	*spp.*		*Potamogetonaceae*	*A. fragariae*	(55)
Potentilla	*alpina* (Willk.) Zimmeter		*Rosaceae*	*A. fragariae*	(18)
Potentilla	*anserina* L.	goose grass, silverweed cinquefoil, wild tansy	*Rosaceae*	*A. ritzemabosi*	(29)
Potentilla	*fragiformis* Willd. ex Schltdl.	strawberry cinquefoil	*Rosaceae*	*A. fragariae*	(33)
Prenanthes	*alba* L.	rattlesnake root, white rattlesnake root, white lettuce	*Asteraceae*	*A. ritzemabosi*	(18)
Primula	*anisiaca* Stapf		*Primulaceae*	*A. fragariae*	(5)
Primula	*angustifolia* var. *helenae* Pollard & Cockerell		*Primulaceae*	*A. fragariae*	(18)
Primula	*auricula* L.	auricula, dusty miller, bear's ear	*Primulaceae*	*A. fragariae*	(18)
Primula	*beesiana* Forr.	candelabra primula	*Primulaceae*	*A. fragariae*	(18)
Primula	*denticulata* Sm.	drumstick primula	*Primulaceae*	*A. fragariae*	(5)
Primula	*denticulata cachemiriana*		*Primulaceae*	*A. fragariae*	(5)
Primula	*flaccida* N. P. Balakr.		*Primulaceae*	*A. fragariae*	(33)
Primula	*japonica* A. Gray		*Primulaceae*	*A. fragariae*	(18)
Primula	*luteola* Ruprecht		*Primulaceae*	*A. fragariae*	(18)

Table 1. Continued

Primula	*malacoides* Franch.	baby primrose, fairy primrose	*Primulaceae*	*A. fragariae*	(18)
Primula	*obconica* Hance	German primrose, poison primrose	*Primulaceae*	*A. fragariae*	(5)
Primula	×*polyantha* Mill.	polyanthus primula	*Primulaceae*	*A. ritzemabosi, A. fragariae*	(18)
Primula	*pulverulenta* Duthie		*Primulaceae*	*A. fragariae*	(18)
Primula	*rosea* Royle		*Primulaceae*	*A. fragariae*	(5)
Primula	*wanda*		*Primulaceae*	*A. ritzemabosi*	(18)
Primula	*wilsonii* Dunn		*Primulaceae*	*A. fragariae*	(18)
Prosartes	*maculata (Buckley) A. Gray*		*Liliaceae*	*A. fragariae*	(72)
Prunus	*cerasus* L.	sour cherry, tart cherry, pie cherry	*Rosaceae*	*A. ritzemabosi*	(18)
Psychotria	*nervosa* Sw.		*Rubiaceae*	*A. fragariae*	(37)
Pteris	*alexandriae*		*Pteridaceae*	*A. fragariae*	(5)
Pteris	*altissima* Poir.	tall brake	*Pteridaceae*	*A. fragariae*	(18)
Pteris	altissima repandula		Pteridaceae	*A. fragariae*	(5)
Pteris	biaurita allosora		Pteridaceae	*A. fragariae*	(18)
Pteris	*biaurita* var. *repandula* (Link) Kauh		*Pteridaceae*	*A. fragariae*	(18)
Pteris	*cretica* L.	Cretan brake	*Pteridaceae*	*A. fragariae*	(5)
Pteris	*dentata* Forssk.		*Pteridaceae*	*A. fragariae*	(5)
Pteris	*denticulata* Sw.	toothed brake	*Pteridaceae*	*A. fragariae*	(5)
Pteris	*droogmansiana*		*Pteridaceae*	*A. fragariae*	(18)
Pteris	*longifolia* L.		*Pteridaceae*	*A. fragariae*	(5)
Pteris	*multifida* Poir.	Chinese brake, spider brake, spider fern	*Pteridaceae*	*A. fragariae*	(5)
Pteris	*ouvrardi*		*Pteridaceae*	*A. fragariae*	(18)

Table 1. Continued

Pteris	*pellucida* C.Presl		*Pteridaceae*	*A. fragariae*	(5)
Pteris	*podophylla* Sw.		*Pteridaceae*	*A. fragariae*	(18)
Pteris	*quadriaurita* Retz.		*Pteridaceae*	*A. fragariae*	(18)
Pteris	*serrulata* Forssk.		*Pteridaceae*	*A. fragariae*	(18)
Pteris	*tremula* R. Br.	Australian brake, shaking brake, tender brake fern	*Pteridaceae*	*A. fragariae*	(5)
Pteris	*umbrosa* R. Br.	jungle brake	*Pteridaceae*	*A. fragariae*	(18)
Pteris	*vittata* L.	Chinese brake, Chinese ladder brake, ladder brake	*Pteridaceae*	*A. fragariae*	(12)
Pulmonaria	*officinalis* L.	hundreds-and-thousands, lungwort, Joseph-and-Mary	*Boraginaceae*	*A. fragariae*	(18)
Pyrrosia	*lingua* (Thunb.) Farw.	felt fern, pyrrosia, tongue fern	*Polypodiaceae*	*A. fragariae*	(42)
Pyrus	*spp.*		*Rosaceae*	*A. fragariae*	(5)
Ranunculus	*acer* L.		*Ranunculaceae*	*A. ritzemabosi*	(18)
Ranunculus	*acris* L.	meadow buttercup, tall buttercup	*Ranunculaceae*	*A. ritzemabosi*	(33)
Ranunculus	*alpestris* L.	alpine buttercup	*Ranunculaceae*	*A. fragariae*	(5)
Ranunculus	*auricomus* L.		*Ranunculaceae*	*A. ritzemabosi*	(18)
Ranunculus	*montanus* Willd.		*Ranunculaceae*	*A. fragariae*	(5)
Ranunculus	*repens* L.	creeping buttercup	*Ranunculaceae*	*A. ritzemabosi*	(5, 33)
Ranunculus	*speciosus* Plenus.	large double buttercup	*Ranunculaceae*	*A. fragariae*	(57)
Rodgersia	*podophylla* A. Gray		*Saxifragaceae*	*A. fragariae*	(18)
Rodgersia	*purdomii* hort.		*Saxifragaceae*	*A. fragariae*	(18)
Rodgersia	*sambucifolia* Hemsl.		*Saxifragaceae*	*A. fragariae*	(18)

Table 1. Continued

Rheum	*rhabarbarum* L.	rhubarb	*Polygonaceae*	*A. ritzemabosi*	(33)
Rhododendron	*indicum* (L.) Sweet		*Ericaceae*	*A. fragariae*	(12)
Rhododendron	*spp.*		*Ericaceae*	*A. fragariae*	(12)
Ribes	*nigrum* L.	black currant	*Grossulariaceae*	*A. ritzemabosi*	(5)
Ribes	*rubrum* L.	common currant, garden currant, red currant	*Grossulariaceae*	*A. ritzemabosi*	(33)
Ribes	*sanguineum* Pursh	red-flower currant, winter currant	*Grossulariaceae*	*A. ritzemabosi*	(18)
Ribes	*uva-crispa* L.	gooseberry	*Grossulariaceae*	*A. fragariae, A. ritzemabosi*	(5, 29, 33)
Rosa	*spp.*		*Rosaceae*	*A. besseyi*	(12)
Rubus	*fruticosus* auct. aggr.	European blackberry	*Rosaceae*	*A. ritzemabosi*	(33)
Rubus	*idaeus* L.	red raspberry	*Rosaceae*	*A. ritzemabosi*	(18, 33)
Rubus	*taiwanicola* Koidzumi & Ohwi	Taiwan raspberry	*Rosaceae*	*A. fragariae*	(42)
Rubus	*ursinus* Cham. & Schltdl.	California blackberry, Pacific dewberry	*Rosaceae*	*A. ritzemabosi*	(33)
Rudbeckia	*fulgida* Aiton	orange coneflower	*Asteraceae*	*ritzemabsoi*	(18)
Rudbeckia	*fulgida* Aiton var. *speciosa* (Wender.) Perdue	orange coneflower	*Asteraceae*	*A. fragariae*	(5)
Rudbeckia	*hirta* L.	black-eyed-Susan	*Asteraceae*	*A. besseyi*	(12)
Rudbeckia	*laciniata* L.	cut-leaf coneflower, tall coneflower	*Asteraceae*	*A. ritzemabosi*	(18)
Rudbeckia	*maxima* Nutt.	cabbage coneflower, giant coneflower	*Asteraceae*	*Aphelenchoides*	(73)
Rudbeckia	*newmani* Loud.		*Asteraceae*	*A. ritzemabosi, A. fragariae*	(18)

Table 1. Continued

Rudbeckia	*nitida* Nutt.	black-eyed-Susan, shiny coneflower, St. John's-Susan	*Asteraceae*	*A. ritzemabosi*	(5, 29)
Rumex	*alpinus* L.	alpine dock, butter dock, mountain rhubarb	*Polygonaceae*	*A. fragariae*	(18)
Rumex	*sagittatus* Thunb.	climbing dock, rambling dock, turkey rhubarb	*Polygonaceae*	*A. ritzemabosi*	(33)
Ruscus	*hypophyllum* L.	Florida ruscus, Holland ruscus, Israeli ruscus	*Liliaceae*	*A. fragariae*	(45)
Sagittaria	*subulata* (L.) Buchenau		*Alismataceae*	*A. fragariae*	(12)
Saintpaulia	*ionantha* H. Wendl.	African violet	*Gesneriaceae*	*A. ritzemabosi, A. fragariae*	(5, 18)
Saintpaulia	*magungensis* E.P.Roberts		*Gesneriaceae*	*A. fragariae*	(41)
Salix	*reticulata* L.		*Salicaceae*	*A. ritzemabosi*	(18)
Salvia	*cacaliaefolia* Benth.	ivy leaf sage, Guatemalan blue vine sage, Gentian leaf sage	*Lamiaceae*	*A. fragariae*	(42)
Salvia	*chiapensis* Fernald	meadow sage, Chiapas sage	*Lamiaceae*	*A. fragariae*	(42)
Salvia	*corrugata* Vahl.	sage	*Lamiaceae*	*A. fragariae*	(42)
Salvia	*farinacea* Benth.	mealy sage, mealy-cup sage	*Lamiaceae*	*A. ritzemabosi, A. fragariae*	(18)
Salvia	*farreri* var *glechomifolia*		*Lamiaceae*	*A. fragariae*	(42)
Salvia	*greggii* A. Gray	autumn sage	*Lamiaceae*	*A. fragariae*	(42)
Salvia	*microphylla* Kunth	baby sage	*Lamiaceae*	*A. fragariae*	(42)
Salvia	*officinalis* L.	sage	*Lamiaceae*	*A. ritzemabosi*	(18)
Salvia	*pratensis* L.	meadow clary, meadow sage	*Lamiaceae*	*A. ritzemabosi*	(18)
Salvia	*spp.*		*Lamiaceae*	*A. fragariae*	(5)
Salvia	*splendens* Sellow ex Schult.	bonfire salvia, scarlet sage	*Lamiaceae*	*A. fragariae*	(5)

Table 1. Continued

Salvia	×*superba* Stapf	perennial sage	*Lamiaceae*	*A. ritzemabosi*	(29)
Salvia	*sylvestris* L.	wild sage, woodland sage	*Lamiaceae*	*A. ritzemabosi*	(18)
Salvia	*uliginosa* Benth	bog sage	*Lamiaceae*	*A. fragariae*	(42)
Sambucus	*racemosa* L.		*Caprifoliaceae*	*A. ritzemabosi*	(18)
Sansevieria	*spp.*		*Agavaceae*	*A. fragariae*	(33)
Saxifraga	*decipiens* Ehrh.		*Saxifragaceae*	*A. fragariae*	(18)
Saxifraga	*peltata* (Torr. ex Benth.) Voss	Indian rhubarb	*Saxifragaceae*	*A. fragariae*	(5)
Saxifraga	*rotundifolia* L.		*Saxifragaceae*	*A. fragariae*	(18)
Saxifraga	*stolonifera* Meerb.	creeping saxifrage, roving sailor	*Saxifragaceae*	*A. ritzemabosi, A. fragariae*	(18)
Saxifraga	*x superba* Rouy & Camus.		*Saxifragaceae*	*A. fragariae*	(56)
Scabiosa	*caucasica* M. Bieb.		*Saxifragaceae*	*A. ritzemabosi, A. fragariae*	(18)
Scabiosa	*columbaria* L.	pigeon's scabious, scabious	*Saxifragaceae*	*A. ritzemabosi, A. fragariae*	(18)
Scabiosa	*lucida* Vill.		*Saxifragaceae*	*A. ritzemabosi, A. fragariae*	(18)
Scabiosa	*silenifolia* Waldst. & Kit.		*Saxifragaceae*	*A. fragariae*	(5)
Scilla	*spp.*		*Liliaceae*	*A. fragariae*	(5)
Scrophularia	*vernalis* L.	yellow figwort	*Scrophulariaceae*	*A. fragariae*	(18)
Sempervivum	*spp.*		*Crassulaceae*	*A. fragariae*	(5)
Senecio	*alpinum*		*Asteraceae*	*A. ritzemabosi*	(29)
Senecio	*clivorum* Maxim.		*Asteraceae*	*A. fragariae*	(18)
Senecio	*nemorensis* L.	alpine ragwort	*Asteraceae*	*A. fragariae*	(18)
Senecio	*petasitis* (Sims) DC.	velvet groundsel	*Asteraceae*	*A. ritzemabosi*	(33)
Senecio	*vulgaris* L.	common groundsel, groundsel	*Asteraceae*	*A. ritzemabosi*	(5), (33)

Table 1. Continued

Serapias	*palustris* (L.) Mill.		*Orchidaceae*	*A. fragariae*	(5)
Setaria	*viridis* (L.) Beauv.		*Poaceae*	*A. besseyi*	(18)
Silene	*elisabethae* Jan	Elisabeth's campion	*Caryophyllaceae*	*A. fragariae*	(18)
Silene	*schafta* S.G.Gmel. ex Hohen	moss campion	*Caryophyllaceae*	*A. ritzemabosi*	(29)
Sinningia	*speciosa* (Lodd. et al.) Hiern	florist's gloxinia, gloxinia, violet slipper gloxinia	*Gesneriaceae*	*A. ritzemabosi, A. fragariae*	(5, 33)
Sisyrinchium	*palmifolium* L.	bird of paradise	*Iridaceae*	*A. fragariae*	(42)
Solanum	*nigrum* L.	black nightshade, common nightshade, poison berry	*Solanaceae*	*A. ritzemabosi*	(18, 33)
Solenostemon	*scutellarioides* (L.) Codd	coleus, painted-nettle	*Lamiaceae*	*A. besseyi*	(18)
Solenostemon	*scutellarioides (L.) Codd*	coleus, painted-nettle	*Lamiaceae*	*A. ritzemabosi*	(18)
Solenostemon	*spp.*	coleus, painted-nettle	*Lamiaceae*	*A. fragariae*	(5)
Solidago	*rupestris*		*Asteraceae*	*A. ritzemabosi*	(18)
Sonchus	*arvensis* L.	perennial sow thistle, corn sow thistle	*Asteraceae*	*A. ritzemabosi*	(18)
Sonchus	*oleraceus* L.	annual sow thistle, hare's-lettuce	*Asteraceae*	*A. ritzemabosi*	(18, 33)
Spirea	*aruncus* L.		*Saxifragaceae*	*A. fragariae*	(18)
Sporobolus	*indicus* (L.) R. Br. var. *indicus*	smut grass	*Poaceae*	*A. besseyi*	(12)
Stachys	*alopecuros* (L.) Benth.	yellow betony	*Lamiaceae*	*A. fragariae*	(18)
Stachys	*longifolia* Benth.		*Lamiaceae*	*A. fragariae*	(18)
Stachys	*macrantha* (K. Koch) Stearn		*Lamiaceae*	*A. ritzemabosi*	(29)
Stachys	*officinalis* (L.) Trevis.	bishop's-wort, purple betony, wood betony	*Lamiaceae*	*A. fragariae*	(18)

Table 1. Continued

Stachys	*palustris* L.	hedge nettle, marsh betony, woundwort	*Lamiaceae*	*A. fragariae*	(18)
Stachys	*sylvatica* L.		*Lamiaceae*	*A. ritzemabosi*	(18)
Stellaria	*media* (L.) Vill.	chickweed	*Caryophyllaceae*	*A. ritzemabosi*	(18)
Stenochlaena	*tenuifolia* (Desv.) T. Moore	holly fern	*Blechnaceae*	*A. fragariae*	(18)
Stenoglottis	*longifolia* Hook.f.		*Orchidaceae*	*A. fragariae*	(5)
Strelitzia	*reginae* Aiton	bird-of-paradise, craneflower	*Strelitziaceae*	*A. fragariae*	(33)
Streptocarpus	*spp.*		*Gesneriaceae*	*A. fragariae*	(1)
Strobilanthes	*dyerianus* Mast	Persian shield	*Acanthaceae*	*A. fragariae*	(5)
Symphyotrichum	*dumosum* (L.) G. L. Nesom	rice button aster, bushy aster, long-stalk aster	*Asteraceae*	*A. ritzemabosi*	(18)
Symphyotrichum	*ericoides* (L.) G.L. *Nesom* var. *ericoides*	white heath aster	*Asteraceae*	*A. fragariae*	(42)
Symphyotrichum	*novi-belgii* (L.) G. L. Nesom	New York aster, Michaelmas daisy	*Asteraceae*	*A. ritzemabosi*	(18)
Symphyotrichum	*tradescantii* (L.) G. L. Nesom	Trandescant's aster	*Asteraceae*	*A. ritzemabosi*	(5, 29)
Symphytum	*asperum* Lepech.	prickly comfrey, rough comfrey	*Boraginaceae*	*A. fragariae*	(18)
Symphytum	*officinale* L.	common comfrey, healing-herb, consound	*Boraginaceae*	*A. fragariae*	(33)
Symphytum	*officinale* L.	common comfrey, healing-herb, consound	*Boraginaceae*	*A. ritzemabosi*	(29)
Symphytum	*x uplandicum Nyman*		*Boraginaceae*	*A. fragariae*	(33)
Tagetes	*spp.*		*Asteraceae*	*A. besseyi*	(18)
Tagetes	*spp.*		*Asteraceae*	*A. ritzemabosi*	(29)
Tanacetum	*balsamita* L. subsp. *balsamitoides* (Sch. Bip.) Grierson		*Asteraceae*	*A. ritzemabosi*	(18)

Table 1. Continued

Tanacetum	*cinerariifolium* (Trevir.) Sch. Bip.	Dalmatia pyrethrum, Dalmatian insect flower, pyrethrum	*Asteraceae*	*A. ritzemabosi*	(18)
Tanacetum	*coccineum* (Willd.) Grierson	painted daisy, Persian insect-flower, pyrethrum	*Asteraceae*	*A. ritzemabosi*	(18)
Tanacetum	*corymbosum* (L.) Sch. Bip. subsp. *corymbosum*		*Asteraceae*	*A. ritzemabosi*	(29)
Tanacetum	*parthenium* (L.) Sch. Bip.	feverfew, altamisa	*Asteraceae*	*A. ritzemabosi*	(18)
Taraxacum	*officinale* F. H. Wigg. aggr.	dandelion, lion's-tooth	*Asteraceae*	*A. ritzemabosi*	(18)
Tectaria	*barteri* (J.Sm.) C.Chr.		*Dryopteridaceae*	*Aphelenchoides*	(5)
Tectaria	*heracleifolia* (Willd.) Underw.		*Dryopteridaceae*	*A. fragariae*	(12)
Tectaria	*polymorpha* (Wall. ex Hook.) Copel.		*Dryopteridaceae*	*Aphelenchoides*	(5)
Tectaria	*siifolia* (Willd.) Copel.		*Dryopteridaceae*	*A. fragariae*	(18)
Tellima	*grandiflora* (Pursh) Dougl. ex Lindl.	bigflower tellima, fringe-cup	*Saxifragaceae*	*A. fragariae*	(18)
Teucrium	*arduini* L.		*Lamiaceae*	*A. fragariae*	(18)
Teucrium	*chamaedrys* L.	wall germander	*Lamiaceae*	*A. fragariae*	(18)
Thelypteris	*dentata* (Forsk) St.John.	maiden fern	*Thelypteridaceae*	*A. fragariae*	(42)
Thelypteris	*hexagonoptera* (Michx.) Fée	broad beechfern	*Thelypteridaceae*	*A. fragariae*	(72)
Thelypteris	*reptans* (J.F. Gmel.) Morton	creeping maiden fern	*Thelypteridaceae*	*A. fragariae*	(12)
Tiarella	*cordifolia* L.	foamflower	*Saxifragaceae*	*A. fragariae*	(42)
Tithonia	*diversifolia* (Hemsl.) Gray	Mexican-sunflower, shrub sunflower	*Asteraceae*	*A. besseyi*	(18)
Todea	*barbara* (L.) T.Moore	todea fern	*Osmundaceae*	*A. fragariae*	(33)
Tolmiea	*menziesii* (Pursh.) Torr.& A.Gray.	piggyback plant, youth-on-age, thousand mothers	*Saxifragaceae*	*A. fragariae*	(63)
Torenia	*fournieri* Linden ex E. Fourn.	bluewings, wishbone flower	*Scrophulariaceae*	*A. besseyi*	(18)
Tovara	*virginiana* (L.) Raf.	jump seed, painter's palette	*Polygonaceae*	*A. fragariae*	(42)

Table 1. Continued

Tradescantia	*pallida* (Rose) D. R. Hunt	purpleheart	*Commelinaceae*	*A. besseyi*	(12)
Tradescantia	*virginiana* L.	Virginia spiderwort, widow's-tears	*Commelinaceae*	*A. fragariae*	(18)
Tradescantia	*zebrina* hort. ex Bosse	wandering-Jew, inchplant	*Commelinaceae*	*A. fragariae*	(18)
Tricyrtis	*hirta* (Thunb.) Hook.	hairy toad lily	*Liliaceae*	*A. fragariae*	(42)
Tricyrtis	*macrantha* Maxim.	toad lily	*Liliaceae*	*A. fragariae*	(42)
Trientalis	*borealis* Raf.		*Primulaceae*	*A. fragariae*	(72)
Trifolium	*pratense* L.	purple clover, red clover, peavine clover	*Fabaceae*	*A. ritzemabosi*	(18)
Trifolium	*repens* L.	Dutch clover, white clover, ladino clover	*Fabaceae*	*A. fragariae*	(5)
Trillium	*grandiflorum* (Michx.) Salisb.	large white trillium	*Liliaceae*	*A. ritzemabosi*	(18)
Trillium	*rugelii* Rendle	ill-scented wakerobin	*Liliaceae*	*A. fragariae*	(42)
Triosteum	*fargesii* Franch.		*Caprifoliaceae*	*A. fragariae*	(18)
Tulipa	*spp.*		*Liliaceae*	*A. ritzemabosi*	(29)
Ulmus	*spp.*		*Ulmaceae*	*A. fragariae*	(5)
Urtica	*dioica* L.		*Urticaceae*	*A. ritzemabosi*	(18)
Urtica	*urens* L.	burning nettle, dwarf nettle, small nettle	*Urticaceae*	*A. ritzemabosi*	(18)
Utricularia	*foliosa* L.		*Lentibulariaceae*	*A. fragariae*	(12)
Valeriana	*montana* L.	mountain valerian	*Valerianaceae*	*A. ritzemabosi*	(5, 29)
Vanda	*spp.*		*Orchidaceae*	*A. besseyi, A. fragariae*	(18)
Verbena	*candensis* (L.) Britton	rose verbena	*Verbenaceae*	*A. fragariae*	(42)
Verbena	*rigida* Spreng. var. *rigida*		*Verbenaceae*	*A. ritzemabosi*	(5, 29)

Table 1. Continued

Verbena	*tenuisecta* Briq.	moss verbena	*Verbenaceae*	*A. fragariae*	(42)
Verbena	*x hybrida*		*Verbenaceae*	*A. fragariae*	(42)
Veronica	*spp.*		*Scrophulariaceae*	*A. ritzemabosi*	(29, 33)
Veronica	*agrestis* L.	field speedwell	*Verbenaceae*	*A. ritzemabosi*	(18)
Veronica	*grandis* Fisch. ex Spreng.	heartleaf speedwell	*Verbenaceae*	*A. ritzemabosi*	(18)
Veronica	*incana* L.		*Verbenaceae*	*A. ritzemabosi*	(18)
Veronica	*spicata* L.	spiked speedwell	*Verbenaceae*	*A. ritzemabosi*	(18)
Veronica	*spicata*		*Verbenaceae*	*A. fragariae*	(42)
Viburnum	×*bodnantense* Aberc.		*Adoxaceae*	*A. ritzemabosi*	(57)
Viola	*odorata* L.	English violet, garden violet, sweet violet	*Violaceae*	*A. fragariae*	(5)
Viola	*spp.*		*Violaceae*	*A. fragariae*	(5)
Viola	*uliginosa* Besser		*Violaceae*	*A. fragariae*	(18)
Vitex	*negundo* L.	Chinese chastetree, five-leaf chastetree	*Verbenaceae*	*A. fragariae*	(12)
Waldsteinia	*fragarioides* (Michx.) Tratt.	barren strawberry	*Rosaceae*	*A. fragariae*	(72)
Woodwardia	*fimbriata* Sm.	giant chain fern	*Blechnaceae*	*A. fragariae*	(18)
Wulfenia	*carinthiaca* Jacq.	cow's footstep wulfenia	*Plantaginacea*	*A. fragariae*	(51)
x Heucherella	*spp.*	heucherella, foamy bells	*Saxifragaceae*	*A. fragariae*	(42)
Xanthium	*strumarium* L. var. *canadense* (Mill.) Torr. & A. Gray	cocklebur	*Asteraceae*	*A. fragariae*	(5)
Zantedeschia	*aethiopica* (L.) Spreng.	calla-lily, arum-lily, trumpet-lily	*Araceae*	*A. fragariae*	(33)
Zinnia	*haageana* Regel	Mexican zinnia, panochit	*Asteraceae*	*A. ritzemabosi*	(18)
Zinnia	*violacea* Cav.	common zinnia, youth-and-old-age	*Asteraceae*	*A. besseyi, A. ritzemabosi, A. fragariae*	(5, 18)

Population dynamics and dispersal gradient of *Aphelenchoides fragariae* in the woody ornamental *Lantana camara*

INTRODUCTION:

Foliar nematodes (*Aphelenchoides fragariae, A. ritzemabosi*, and *A. besseyi*) cause a widespread disease in greenhouse, nursery, and landscape ornamentals plants (Juhl, 1978; Knight et al., 1997; McCuiston et al., 2007; Wick, 1995) because the nematodes feed endoparasitically on leaf tissue, causing chlorotic, vein-delimited lesions, stunting, and defoliation (Siddiqi, 1975) that can render ornamental plants unsaleable. Understanding the temporal and spatial epidemiology of foliar nematodes in ornamental crops in greenhouses and nurseries is important for developing integrated management practices, because chemical controls are limited in availability and efficacy (Jagdale and Grewal, 2002; LaMondia, 1999). Current management recommendations include avoiding overhead irrigation, destroying infected plant material, and sanitation (Daughtrey et al., 1995). There are a limited number of studies on the effect of environmental variables on the temporal population changes of *A. fragariae*. In Poland, populations of *A. fragariae* in strawberries increased in the late fall and early spring, during months when the air temperature was low and the relative humidity was high (Szczygiel and Hasior, 1971, 1972). In Japan, populations of *A. fragariae* in lilies increased during the rainy season (Yamada and Takakura, 1987). Jagdale and Grewal (2006) determined that adult

nematodes migrating on the outside of hosta leaves had a higher survival rate at 100% relative humidity versus decreased survival rates at lower relative humidity levels.

Limited research has been done on the spatial movement of *Aphelenchoides* in plant nurseries. Foliar nematodes spread to new leaves on a single plant, and from plant to plant, primarily by migrating through films of water over plant surfaces (Wallace, 1959). *Aphelenchoides fragariae* can spread to new plants when moisture is present and infected plant tissue including leaves, plantlets, and the surfaces of seeds, come in contact with healthy tissue. In greenhouses and nurseries overhead irrigation and rainfall allows foliar nematodes to move by splash dispersal from plant to plant (Lehman, 1996; Marlatt, 1970). Hesling and Wallace (1961) observed that uninfected chrysanthemum plants growing in the same block as infected plants under overhead irrigation became infected with *A. ritzemabosi* after two months. Symptomatic leaves were observed in plants growing as far away as 76 cm away from the original infection source; however, whether individual plant canopies were allowed to touch over the growing season was unclear (Hesling and Wallace, 1961). The dispersal gradient for *A. fragariae* in nursery crop production under overhead irrigation has not yet been determined.

The objectives of this research were to (i) determine what environmental variables were correlated to *A. fragariae* population dynamics in a woody ornamental, *Lantana camara*, during the growing season and during overwintering in a commercial nursery,

and (ii) to determine the dispersal gradient of *A. fragariae* in a nursery with overhead irrigation.

MATERIALS AND METHODS

Foliar nematode population dynamics: The distribution and population densities of foliar nematodes in lantana plants (*Lantana camara*) grown at a commercial nursery in Pender County, North Carolina, were monitored during the 2006, 2007, and 2008 growing seasons. Each season a new set of thirty 'Miss Huff' lantana plants, each infected with *A. fragariae*, with canopies approx. 30 cm in height and 15 cm in width and grown in 13.2 liter containers of pine bark were placed in a block on a nursery pad spaced 60 cm apart from one another. These plants had been overwintered in a polyhouse at the nursery in 4.4 liter containers, and then transplanted into the 13.2 liter containers in April of each growing season. The thirty infected plants were placed on the nursery pad outside by May of each season. The block of infected plants was irrigated by overhead sprinklers for 5-10 minutes in the early morning, around midday, and then in the afternoon each day. Plants were pruned to half their height once a month after sampling to shape the plants and mimic typical nursery practices. Air temperature, relative humidity, and rainfall data were recorded at the nursery with a weather station (GroWeather, Davis Instruments, Hayward, California). On occasion data skips occurred so missing weather data was filled in using

weather station data from the Horticultural Crops Research station located 50 kilometers away in Castle Hayne, NC.

Plant sampling: During the 2006 growing season, from 6 June to 25 September, only symptomatic leaf samples were sampled from the block of thirty infected plants. Five leaves were collected from each plant every 2 weeks by sampling from the bottom and middle tier of each plant. During the 2007 growing season, from May 16th to October 17th, symptomatic, asymptomatic, and defoliated leaf samples were collected. In 2008, symptomatic, asymptomatic, and defoliated leaf samples were collected from May 28th to August 27th. Three asymptomatic and three symptomatic leaves were sampled from the middle tier of the plant, and three asymptomatic and three symptomatic leaves were then sampled from the bottom tier of the plant. The asymptomatic leaves sampled were growing adjacent to the symptomatic leaves sampled so nematode migration into asymptomatic leaves could be studied. If symptomatic leaves were not present, asymptomatic leaves were arbitrarily collected in accordance with the sampling pattern. All asymptomatic and symptomatic leaf samples were collected from at least two different stems of each lantana plant. Two to four defoliated leaf samples were collected from dead lantana leaves on the container surface. Only brown and dried defoliated leaf material was collected. The lantana pots were cleared of all defoliated leaves once a month so all defoliated leaf samples would have a maximum age of 30 days at the next sampling date. Symptomatic and asymptomatic leaves were placed in 50 ml plastic centrifuge tubes,

while defoliated leaves were collected in re-sealable 16.5 cm x 8.25 cm plastic bags. The six symptomatic leaves from each plant were considered as one sample, as were the six asymptomatic leaves, and the two to four defoliated from each plant, for a maximum of three sample types per plant, 90 samples total per sampling date. All sampled leaves were transported in a styrofoam cooler, and then kept refrigerated at 3 ^{o}C prior to assay.

Disease severity ratings of each plant were assessed biweekly using the Horsfall-Barratt Scale, a scale that assigns disease severity rankings into 12 numerical classes (Horsfall and Barratt, 1945) during the 2007 season. Symptomatic leaf samples from the 2007 and 2008 seasons were also photographed, and then the percent of diseased leaf tissue for each symptomatic leaf was calculated using Assess (APS Press, St. Paul, Minnesota). The values for the percent of diseased leaf tissue for all the symptomatic samples that contained nematodes were then averaged together to obtain an average percent of symptomatic leaf area for each sampling date.

Nematode assay: All six leaf samples of one sample type from each plant were weighed together, and then cut into small pieces and incubated in 10-15 ml of deionized water at room temperature to stimulate foliar nematode emergence (Esser and Riherd, 1981). After 2 days, the leaf samples and extraction water were placed on nested sieves with a large mesh sieve to remove leaf debris and a 500-mesh (25 µm openings) sieve to collect nematodes that had emerged. Nematodes were washed from the sieve in 5-10 ml of deionized water. The extracted foliar nematode samples were then placed in a

refrigerator at 3 ^{o}C until they were counted. *Aphelenchoides fragariae* were identified using morphological features (Siddiqi, 1975) and counted in a 3 cm by 7.5 cm counting dish using a Nikon inverted microscope at 40x. The total number of *A. fragariae* in the dish was then divided by the total mass of the leaf tissue used in each respective sample to obtain the nematode count per gram of fresh weight leaf tissue. The nematode counts per gram of fresh weight leaf tissue were then averaged together to obtain an average nematode count per gram of fresh weight leaf tissue for each leaf type at each sampling date. The standard error was calculated for the nematode counts at each sampling date. Nematode count data was examined on both a logarithmic and arithmetic scale, and the arithmetic scale was chosen for presentation.

Correlation analysis: The numbers of nematodes per fresh weight of leaf tissue from all 30 plant samples at each sampling date were averaged together to obtain average nematode counts per gram of leaf tissue for the asymptomatic leaves, symptomatic leaves, and defoliated leaves per sample date. The spearman rank correlation test was used to analyze data because this is a robust, non-parametric statistic that makes no prior assumptions about the data. Correlations were run in SAS (SAS Institute, Cary, NC) with the daily maximum air temperature, daily minimum air temperature, daily average air temperature, relative humidity, and rainfall data collected from the onsite weather station. Weather data from 3, 7, 14, and 20 days before each sampling date was averaged and

analyzed in the correlation tests with the arithmetic data of the nematode counts for each sample type.

Overwintering study: At the start of the growing season in each population dynamics study, thirty uninfected 'Miss Huff' lantana plants in 4.4 liter containers of pine bark were placed immediately around the block of thirty 13.2 liter containers to infect the plants in the 4.4 liter containers to study during overwintering and then during the following growing season. In October in both 2006 and 2007 lantana grown in 4.4 liter containers that had been placed around the test area during each growing season were moved into overwintering polyhouses with supplemental heating to maintain a minimum temperature of 30 ^{o}C. As typical of overwintering practices, plants were placed close together such that plant canopies of adjacent plants touched one another. The plants were watered with overhead irrigation in the polyhouse as needed, and the upper, unsampled tier of the plants was pruned once during the winter of 2006-7. Plants were not pruned in the 2007-8 to prevent removing infected tissue. During the 2007-8 winter all leaf debris was cleared from the container surfaces at each sampling date. A weather station (GroWeather, Davis Instruments, Hayward, California) was kept in the polyhouse to record daily temperatures and relative humidity. In April the plants were transplanted into 13.2 liter containers, and then moved back to the nursery pad to conduct another population study.

Symptomatic leaves growing on the plants and defoliated leaves from the container surface in the polyhouse were sampled during both the 2006-7 and 2007-8 overwintering periods at monthly intervals in the same manner as leaves were sampled during the growing season. Asymptomatic leaves growing adjacent to the sampled symptomatic leaves were collected from plants during the 2007-8 winter.

Foliar nematodes were extracted from leaf samples in the same manner as during the growing season. However, only a limited number of symptomatic and infected defoliated leaves were found and collected during the overwintering seasons so the total number of *Aphelenchoides* nematodes in the counting dishes for all leaves collected by sample type was divided by the total number of leaves collected in each respective sample type to obtain the mean nematode count per leaf collected. Weather data from 3, 7, 14, and 20 days before each sampling date was averaged together and used in Spearman correlation tests (SAS) with nematode counts for each sample type.

During 2006-7 winter, potting media was sampled with a 2-cm diameter soil sampling tube and then the missing potting media was replaced with fresh pine bark. Potting media samples were placed in Baermann funnels in a modified Seinhorst mist apparatus (Barker et al., 1986) for 24 hours. Water solutions from these samples were collected in test tubes below the Baermann funnels and then the water solutions were examined for the presence of *Aphelenchoides* nematodes in a 3 cm by 7.5 cm counting

dish with a Nikon inverted microscope at 40x power. No nematodes were recovered in potting mix samples from 2006-7, so samples were not collected in 2007-8.

Dispersal gradient study: Dispersal of foliar nematodes from plant to plant was examined at the Horticultural Field Lab at North Carolina State University in Raleigh, North Carolina from August 3, 2007 to October 12, 2007, and again from July 20, 2008 to October 7, 2008. Sixty uninfected, asymptomatic lantana plants with an average canopy size of 30 cm by 38 cm, which had been transplanted into 4.4 liter containers of pine bark during April of 2007, were obtained from a commercial nursery in North Carolina. Fifteen salvia (*Salvia farinacea)* plants infected with *A. fragariae* in 4.4 liter containers of pine bark were also obtained from the same commercial nursery in 2007. The healthy lantana plants were placed in blocks with one infected salvia plant, with each block consisting of four healthy lantana plants spaced equidistantly around the one infected salvia plant. Three different spacings were used between the canopies of the infected salvia plant and the canopies of the initially healthy lantana plants: 0 cm (touching), 30 cm, and 100 cm. Each spacing distance was replicated five times, so that a total of 20 plants were placed at each spacing distance across the experiment. As the plants grew out, they were moved farther away from the infected salvia plants to maintain the original spacing between plant canopies. Plants were watered twice daily, in the morning and then five hours later, by overhead irrigation for 20 minutes to receive an average of 2.8 cm of

water daily, and there were five rainfall events during the experiment in 2007 totaling 13.06 cm of rain. In 2008 infected lantana plants in 4.4 liter containers were obtained from the same commercial nursery and were used as source plants. The uninfected lantana plants were grown from cuttings taken in March of 2008, and transplanted to 4.4 liter containers of pine bark in June of 2008. In 2008 31.4 cm of rainfall occurred during the experiment. The temperature during both years ranged from a minimum of 12 ^{o}C to a maximum of 40 ^{o}C during the test.

The plants were visually monitored once a week for symptoms of foliar nematode infection. Symptomatic leaves, when found were collected and processed by the water extraction assay method to detect the presence of foliar nematodes. If foliar nematodes were present in a leaf sample, that plant was marked as positive on a plot map. The data are presented as a series of plot maps representing the weekly sampling periods over the experiment.

RESULTS

Population dynamics study: Disease severity across the 30 infected lantana plants increased over the growing season during both 2007 and 2008, but in 2008 the average disease severity of the lantana plants was much less than in 2007 (Fig. 1). The percent area of symptomatic leaf tissue of each leaf sampled was not correlated to the nematode

counts per gram of symptomatic leaf tissue in 2007 (P = 0.0899) and 2008 (P = 0.0724) (Fig. 2).

The population levels of nematodes per gram fresh weight of symptomatic leaf tissue were low at the first sampling dates in May/early June of all three years, remaining at levels under 100 nematodes per gram of leaf tissue (Fig. 2). In June the population levels began to increase, reaching 86 nematodes per gram of symptomatic leaf tissue in June of 2006, 100 nematodes per gram of leaf tissue in June of 2007 and 133 nematodes per gram of leaf tissue in June of 2008. The population levels reached a peak in July in all three years, with average populations of 122 nematodes per gram of symptomatic leaf tissue being record in July of 2006, 407 nematodes per gram of leaf tissue in July of 2007, and 180 nematodes per gram of leaf tissue in 2008. After July the nematode populations then decreased. This decline continued for the remainder of the 2006 and 2008 growing seasons, but in 2007 a second smaller peak occurred in October, when 300 nematodes per gram of leaf tissue were recorded.

At 14 days before sampling, nematode counts per gram of leaf tissue from symptomatic leaves were positively correlated to daily high temperatures (P = 0.0003) and daily low temperatures (P = 0.0010). At 20 days before sampling, nematode counts per gram of symptomatic leaf tissue were positively correlated to daily high temperatures (P = 0.0010). There were no significant correlations with average daily temperatures, relative humidity or rainfall.

The number of foliar nematodes extracted from asymptomatic leaf samples was always very low compared to symptomatic leaves. Although the number of nematodes in asymptomatic leaves was low, this number increased slighty over the 2007 and 2008 growing seasons. The total number of plants with asymptomatic leaves infected with foliar nematodes increased as the symptomatic leaves defoliated from the plants over the end of the growing season (Fig. 3). In 2007 the number of nematodes per asymptomatic leaf and the total number of plants with infected asymptomatic leaves reached its peak in early September, and then decreased for the remainder of the fall. The amount of nematodes per gram of asymptomatic leaf tissue was positively correlated to the total number of plants that had asymptomatic leaves infected with *Aphelenchoides* (P = <0.0001). At 14 days before sampling the number of nematodes per gram of asymptomatic leaf tissue was positively correlated to the daily low temperature (P = 0.0156) and relative humidity (P = 0.0001), and the number of plants that had asymptomatic leaves that were infected with foliar nematodes was positively correlated to relative humidity (P = 0.0008). At 20 days before sampling the nematode count per gram of asymptomatic leaf tissue was positively correlated with humidity (P = 0.0006) and the number of plants that had asymptomatic leaves infected with *Aphelenchoides* also was positively correlated with relative humidity (P = 0.0023).

The number of foliar nematodes in defoliated leaf tissue increased over the 2007 and 2008 growing seasons, remaining at higher levels through July to August of 2007, but

not reaching a peak in 2008 until August when many of the symptomatic leaves had defoliated from the plants (Fig. 4). Two hundred thirty-five nematodes per gram of leaf tissue were counted in August of 2007 and 425 nematodes per gram of defoliated leaf tissue were counted on August 13, 2008, and then the nematode counts from defoliated leaf tissue decreased markedly for the rest of both growing seasons. The number of nematodes per gram of defoliated leaf tissue was positively correlated to the total number of plants that had defoliated leaves that contained foliar nematodes (P = <.0001). When the number of *Aphelenchoides* counted in each defoliated leaf sample was expressed as per gram of defoliated leaf tissue there were no significant correlations for any of the weather variables to the counts. However, when the *Aphelenchoides* counts from defoliated leaves were expressed as the number of nematodes counted per leaf sampled, the nematode counts per leaf were was positively correlated at 7 days before sampling to daily low temperature (P = 0.0127), at 14 days before sampling to daily high temperature (P = 0.0041) and daily low temperature (P = 0.0026), and at 20 days before sampling, the nematode counts per leaf were correlated positively to daily low temperature (P = 0.0096) and humidity (P = 0.0071). The total number of plants with defoliated leaves that were infected with *Aphelenchoides* was positively correlated at 14 days to the daily high temperature (P = 0.0083) and the daily low temperature (P = 0.0056). At 20 days the number of plants that contained infected defoliated leaves was positively correlated to the

daily low temperature ($P = 0.0156$). Nematodes were not found in every defoliated leaf collected, but nematodes were detected in at least one sample during every sampling date.

Overwintering study: In the polyhouses the plants never went into a dormant state; they overwintered with living green tissue throughout the winter season. During the overwintering season plants flushed out with new leaves and the number of symptomatic leaves decreased greatly because many of the symptomatic leaves dropped from the plants early in the overwintering period.

Defoliated and symptomatic leaves were collected in both the 2006-07 and 2007-08 overwintering periods, but often there were not three symptomatic leaves available in the bottom and mid-level canopy nor were many defoliated leaves found after the initial period of defoliation shortly after plants were moved into the polyhouse. To accurately represent the nematode counts in the leaf material during the overwintering period this data was standardized by nematode count per leaf instead of per gram of leaf tissue. This made the data more relevant biologically by anomalies due to small masses of the defoliated leaf tissue, and decreased the standard error of the nematode counts.

In both overwintering periods the population of foliar nematodes in symptomatic leaves remained low until December/January, and then the population levels increased through the rest of the 2006-7 overwintering season, but fluctuated during the 2007-8 overwintering period (Fig. 5). During the 2006-7 overwintering period the nematode count

reached a peak of 70 nematodes per symptomatic leaf, and in the 2007-8 overwintering period the nematode count reached 65 nematodes per symptomatic leaf. The number of nematodes per symptomatic leaf sampled was not correlated ($P > 0.05$) to daily high temperature, daily low temperature, average daily temperature, or relative humidity in the polyhouse.

Defoliated leaf samples were collected from the container surfaces in both overwintering periods, and the number of nematodes per gram of defoliated leaf tissue increased from November to December of 2006, and then held steady into February 2007. During the 2007-08 overwintering period no nematodes were detected in defoliated leaves until February of 2008, and in April of 2008 similar low numbers of nematodes were found in the defoliated leaves (Fig. 6).

Asymptomatic leaves were only sampled during the 2007-08 overwintering period. During this period, the number of nematodes per gram of leaf tissue in the asymptomatic leaves remained very low over the entire overwintering season, never increasing over an average of one nematode per leaf sampled.

Dispersal gradient study: In 2007 symptoms first appeared on lantana plants at the 0 cm spacing from the inoculum source six weeks after the experiment was established. Each plant at this spacing gradually became infected until all four of the plants at the 0 cm spacing in all five replications were infected by week 11 (Fig. 7). Two plants at the 30 cm space became infected, one during week seven, and one during week

nine. A third plant at this spacing began to show symptoms after only two weeks, well before any other plants displayed symptoms, so this plant was considered to have been infected before the experiment began, and was not included in the calculation of the results. One plant at the 100 cm spacing became infected after eight weeks. The sprinkler pattern surrounding this plant was analyzed, and it was observed that the water spray from a nearby sprinkler passed through an infected plant, and that if there was any wind this water spray was blown from the infected salvia plant to the lantana plant that later became infected. In 2007 the dispersal gradient was rather steep, and showed the number of plants that became infected with foliar nematodes greatly decreased as the spacing from the infected source plant increased (Fig. 8).

In 2008 no infected plants were detected until eight weeks after the experiment was established when one plant at the 0 cm spacing became infected. By 12 weeks all of the plants at the 0 cm spacing were infected with *A. fragariae*. At ten weeks one plant at the 30 cm spacing became infected, but no plants at the 100 cm spacing became infected during the 2008 season.

DISCUSSION:

Nematode counts of *A. fragariae* in symptomatic leaf tissue of lantana during the growing season in a commercial nursery were positively correlated to daily air temperatures, which could also signify that the growth stage of the plant had an effect on

the nematode densities within individual leaves, or the temperatures during the growing season could have been optimal temperatures for egg laying and completing the nematode life cycle. Szczygiel and Hasior (1972) determined that higher populations of *A. fragariae* were detected during periods of cool weather and high humidity in Poland, but our peak foliar nematode populations occurred in July, when temperatures were high.

Nematode counts per gram of symptomatic leaf tissue were only correlated with daily air temperatures at 14 and 20 days before sampling. The life cycle of *A. fragariae* can be completed in 14 days (Siddiqi, 1975; Strumpel, 1967), so daily temperatures could be affecting egg-laying of females within leaf tissue. The optimum temperature for egg production in *Aphelenchoides* females is not known, although past studies have demonstrated that *A. fragariae* females lay eggs at 18 ^{o}C (Strumpel, 1967), and females of the related species *A. ritzemabosi* will lay eggs at temperatures from 13 ^{o}C to18 ^{o}C (French and Barraclough, 1961), but the experimenters did not determine the optimum temperature for foliar nematode reproduction and maturation. During the North Carolina growing season, outdoor temperatures ranged from 10 ^{o}C to 36 ^{o}C, and the highest population levels occurred in July/August of all three years, when the average daily air temperature for the fourteen days before sampling was 27 ^{o}C in 2006, 28 ^{o}C in 2007, and 26 ^{o}C in 2008.

Nematode counts per gram of asymptomatic leaf tissue were positively correlated with relative humidity and daily low temperatures at 14 and 20 days before sampling.

Aphelenchoides enter leaf tissue by migrating over plant surfaces in thin films of water (Wallace, 1959). Higher humidity levels would keep plant tissues moist for longer periods of time, allowing foliar nematodes to enter the stomates of healthy, asymptomatic leaves. Once infected, several weeks are required for leaf tissue to become symptomatic as the nematode populations build within the leaf tissue. This may be why we did not see a relationship between humidity and symptomatic leaf tissue. The nematode counts from symptomatic leaf tissue were positively correlated to the nematode counts from asymptomatic leaf tissue though, which could signify that as overall levels of nematodes were increasing in the symptomatic leaf tissue more nematodes were emerging from that symptomatic leaf tissue and migrating to healthy, asymptomatic leaves.

It is important to note that nematodes were found in asymptomatic leaves throughout the growing and overwintering seasons. Asymptomatic plants are often overlooked as a source of inoculum, but our results clearly show that asymptomatic leaves can harbor foliar nematodes. This is a major concern for growers and regulatory officials who want to avoid shipping and buying contaminated plants.

During the growing season *A. fragariae* populations followed a predictable pattern, with the highest nematode densities per gram of symptomatic leaf tissue occurring in July all three years, while overall plant disease severity kept increasing throughout the growing season. If effective chemical controls become available, growers could potentially target the low population levels present after the overwintering period for the

plants is over. Waiting to treat plants until after symptoms have appeared during the growing season is not recommended, because our results show a lag between when nematode populations rise and when symptoms become severe.

Symptomatic and defoliated leaf material was very hard to find during the overwintering period, because symptomatic leaves began to defoliate at the end of the growing season. The plants did continue to flush out and grow new leaves throughout this period though, and this leaf material allowed the foliar nematode infection to remain throughout the overwintering period. Leaf material was always available for infection, which might be a factor in why no nematodes were found in the potting media samples during the 2006-7 overwintering season. Foliar nematodes have a low survival rate in bare soil (Szczygiel and Hasior, 1971) so it is expected that the nematodes would move into fresh leaf tissue if it was available. Our nematode counts in asymptomatic leaves were very low throughout the overwintering period, which may signify a change in the nematode biology during the overwintering period that could be in response to temperature. The lower nematode counts may have also been harder to detect with the extraction method used for the study. While the water assay extraction method allowed quantitative nematode count data to be collected, it is not as sensitive for the detection of foliar nematodes as molecular methods (McCuiston et al., 2007).

During the dispersal gradient study of the 2007 growing season, 100% of the lantana plants at the 0 cm spacing became infected with foliar nematodes within 11 weeks,

but only 10% of the lantana plants at the 30 cm spacing became infected, and only 5% of the lantana plants at the 100 cm spacing became infected over the period of 11 weeks. During the 2008 growing season 100% of the plants at the 0 cm spacing became infected, while only 5% of the plants at the 30 cm spacing became infected, and none of the plants at the 100 cm spacing became infected. In 2008 the plants also took two weeks longer to show signs of infection. This difference could have resulted from using lantana plants, instead of *Salvia* plants, as the source plants in 2008. The lantana plants used a source plants in 2008 also had fewer symptomatic leaves than the *Salvia* plants in 2007, which could have meant that the initial inoculum levels were lower in 2008.

The plants at the 0 cm spacing appeared to take longer to dry after being irrigated, so the films of water covering the plant surfaces of these plants may have provided a favorable environment for dispersalof foliar nematodes for longer periods than the environment around the plants at the greater spacings. These results illustrate why optimizing plant spacing in nurseries could be an important management tool to prevent the spread of foliar nematodes given suitable economic return. Growers bringing new, asymptomatic, but potentially infected, plants into their nurseries may be able to avoid infesting healthy plants with foliar nematodes by maintaining a spacing of over 30 cm between blocks of plants. Based on our dispersal curves, a spacing of 30-40 cm would be an acceptable distance that would greatly decrease the risk of infecting neighboring blocks

of plants. These results also demonstrate why plants infected with foliar nematodes need to be removed from any area where healthy plants are present.

Our results show that air temperature and relative humidity are correlated to *A. fragariae* leaf densities over the growing season and during the overwintering period in polyhouses in North Carolina, and that plant spacing plays an important role in the dispersal of *A. fragariae* in nurseries. Nematode densities in symptomatic leaves were positively correlated with daily high temperatures and daily low temperatures, and nematode densities in asymptomatic and defoliated leaves were positively correlated with daily temperatures and relative humidity. When the plants were overwintered in a polyhouse, nematode counts per asymptomatic leaf sampled were positively correlated with average daily temperatures in the polyhouse. In our experiments 100% of lantana plants with leaf canopies touching the canopies of infected plants became infected with *A. fragariae* after 12 weeks, and plants spaced at 30 cm or farther from infected plants were less likely to become infected.

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LITERATURE CITED:

Barker, K.R., Townshend, J.L., Bird, G.W., Thomason, I.J., and Dickson, D.W. 1986. Determining nematode population responses to control agents. In *Methods for Evaluating Pesticides for Control of Plant Pathogens*, edited by Hickey, K. D. St. Paul, MN: APS Press.

Daughtrey, M.L., Wick, R.L., and Peterson, J.L. 1995. Compendium of flowering potted plant diseases. St. Paul, MN: APS Press.

Esser, R.P., and Riherd, C.C. 1981. Distribution of *Aphelenchoides fragariae* in leaves of *Ficus elastica* and *Asplenium nidus*. Plant Disease 65:425-426.

French, N., and Barraclough, R.M. 1961. Observations on the reproduction of *Aphelenchoides ritzemabosi* (Schwartz). Nematologica 6:89-94.

Hesling, J.J., and Wallace, H.R. 1961. Observations on the biology of chrysanthemum eelworm *Aphelenchoides ritzema-bosi* (Schwartz) Steiner in florists' chrysanthemum. I. Spread of eelworm infestation. Annuals of Applied Biology 49:195-203.

Horsfall, J.G., and Barratt, R.W. 1945. An improved grading system for measuring plant diseases. Phytopathology 35:655-655.

Jagdale, G.B., and Grewal, P.S. 2002. Identification of alternatives for the management of foliar nematodes in floriculture. Pest Management Science 58:451-458.

Jagdale, G.B., and Grewal, P.S. 2006. Infection behavior and overwintering survival of foliar nematodes, *Aphelenchoides fragariae*, on Hosta. Journal of Nematology 38:130-136.

Juhl, V.M. 1978. Liste over vaertplanter for bladnematoden *Aphelenchoides ritzemabosi*. Ugeskr. f. Agron., Hort., Forst., og Lic. 123:183-186.

Knight, K.W.L., Barber, C.J., and Page, G.D. 1997. Plant-parasitic nematodes of New Zealand recorded by host association. Journal of Nematology 29:640-656.

LaMondia, J.A. 1999. Efficacy of insecticides for control of *Aphelenchoides fragariae* and *Ditylenchus dipsaci* in flowering perennial ornamentals. Journal of Nematology 31:644-649.

Lehman, P.S. 1996. Dispersal modes for foliar nematodes. In *Nematology Circular 216*: Florida Department of Agriculture & Consumer Services.

Marlatt, R.B. 1970. Transmission of *Aphelenchoides besseyi* to *Fiscus elastica* leaves via *Sporobolus poiretti* inflorescences. Phytopathology 60:543-544.

McCuiston, J.L., Hudson, L.C., Subbotin, S.A., Davis, E.L., and Warfield, C.Y. 2007. Conventional and PCR detection of *Aphelenchoides fragariae* in diverse ornamental host plant species. Journal of Nematology 39:343-355.

Siddiqi, M.R. 1975. *Aphelenchoides fragariae*. In *Commonwealth Institute of Helminthology Descriptions of Plant-Parasitic Nematodes, no. 74.* Kew, England: Commonwealth Agricultural Bureaux.

Strumpel, H. 1967. Beobachtungen zur Lebensweise von *Aphelenchoides fragariae* in Lorraine-Begonien. Nematologica 13:67-72.

Szczygiel, A., and Hasior, H. 1971. Possibility of persistence of leaf and bud nematodes (*Aphelenchoides fragariae*) on strawberry plants and in the soil. Zeszyty problemowe postepow nauk rolniczych 121:101-106.

Szczygiel, A., and Hasior, H. 1972. Seasonal variations in population of plant parasitic nematodes in strawberry plantations. Ekologia Polska 20:507-522.

Wallace, H.R. 1959. Movement of eelworms. V. Observations on *Aphelenchoides ritzema-bosi* (Schwartz 1912) Steiner 1932 on florists' chrysanthemums. Annals of Applied Biology 47:350-360.

Wick, R.L. 1995. Occurrence of foliar nematodes on woodland plants in a Massachusetts native plant garden. Phytopathology 85:1561.

Yamada, E., and Takakura, S. 1987. Ecological investigations on the strawberry nematode, *Aphelenchoides fragariae* on lilies. Japanese Journal of Nematology 17:1-7.

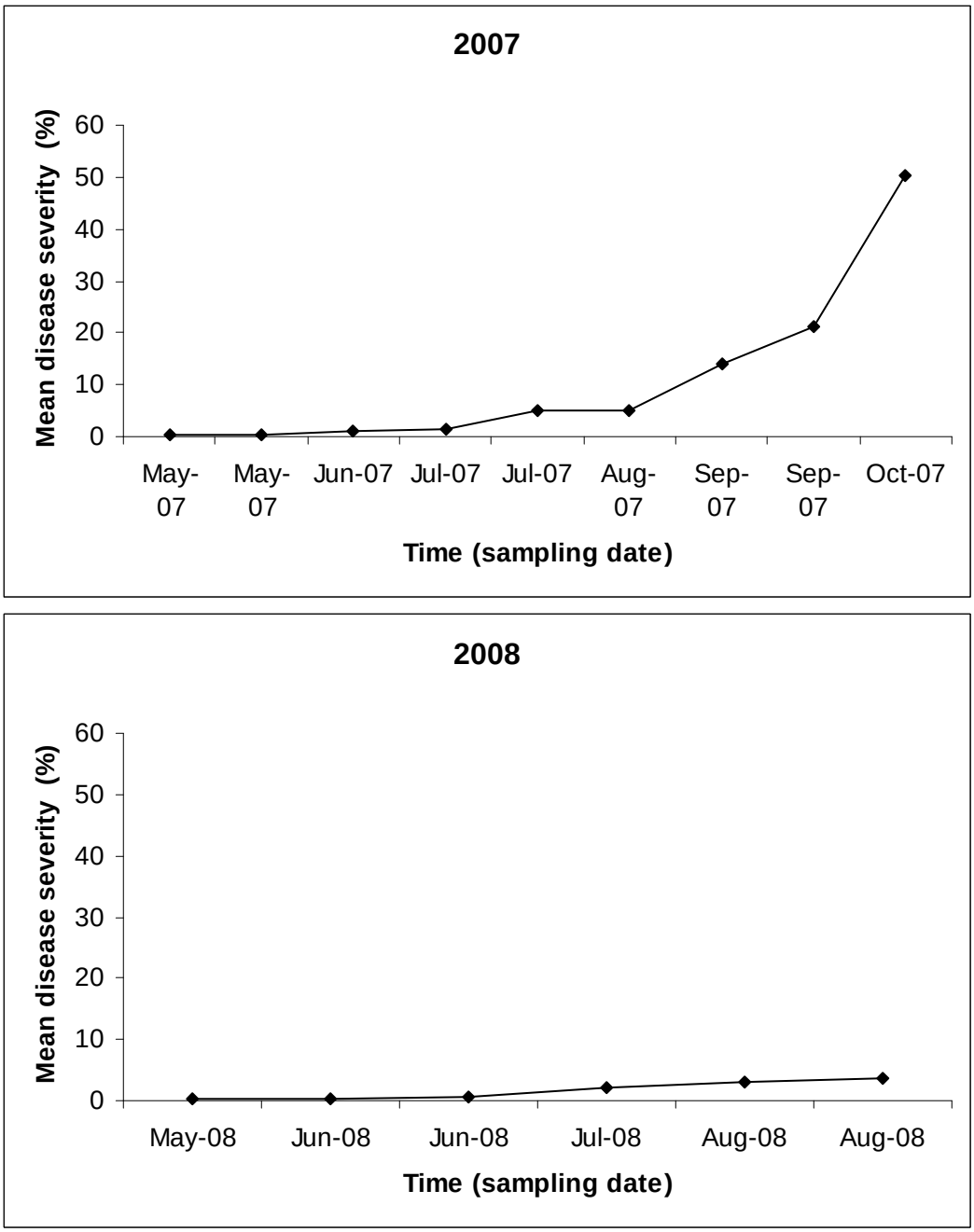


FIG. 1. Disease severity of 30 lantana plants infected with *Aphelenchoides fragariae* that were grown in containers in a commercial nursery with daily overhead irrigation over the 2007 and 2008 growing seasons. The Horsfall-Barratt Scale was used to rate the plants, and the midpoint for each Horsfall-Barratt severity interval was used to graph the results.

FIG. 2. Percent area of symptomatic leaf tissue (dotted line) of 30 lantana plants infected with *Aphelenchoides fragariae* grown in containers in a commercial nursery with daily overhead irrigation over the 2006, 2007, and 2008 growing seasons, compared to the number of *Aphelenchoides fragariae* counted per gram of symptomatic leaf tissue (solid line). The percentage of symptomatic leaf tissue was not measured for the 2006 samples. Each data point for the nematode counts represents the number of average number of nematodes counted per gram of fresh weight leaf tissue from five to six symptomatic leaves sampled from the middle and bottom tiers of each plant.

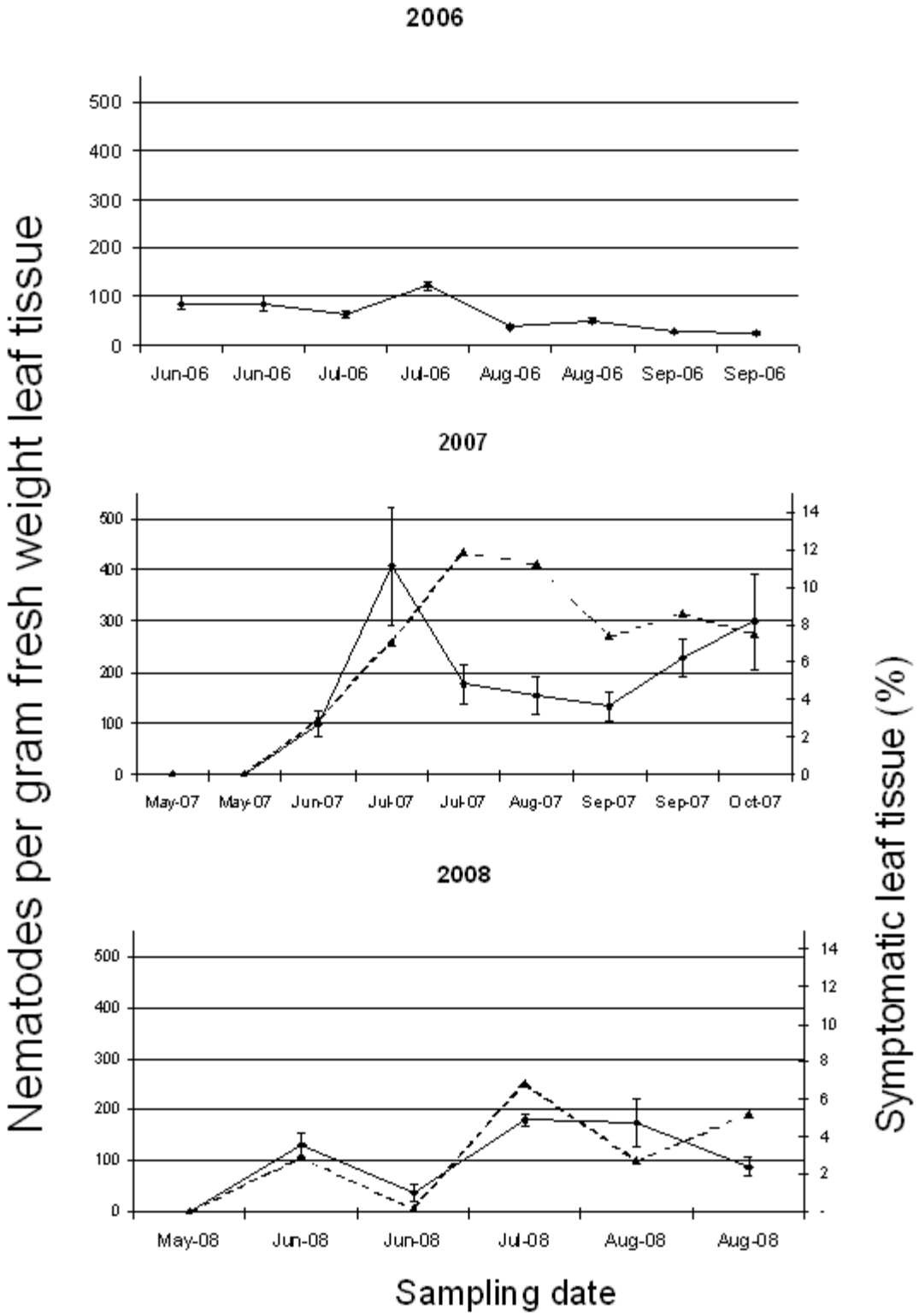
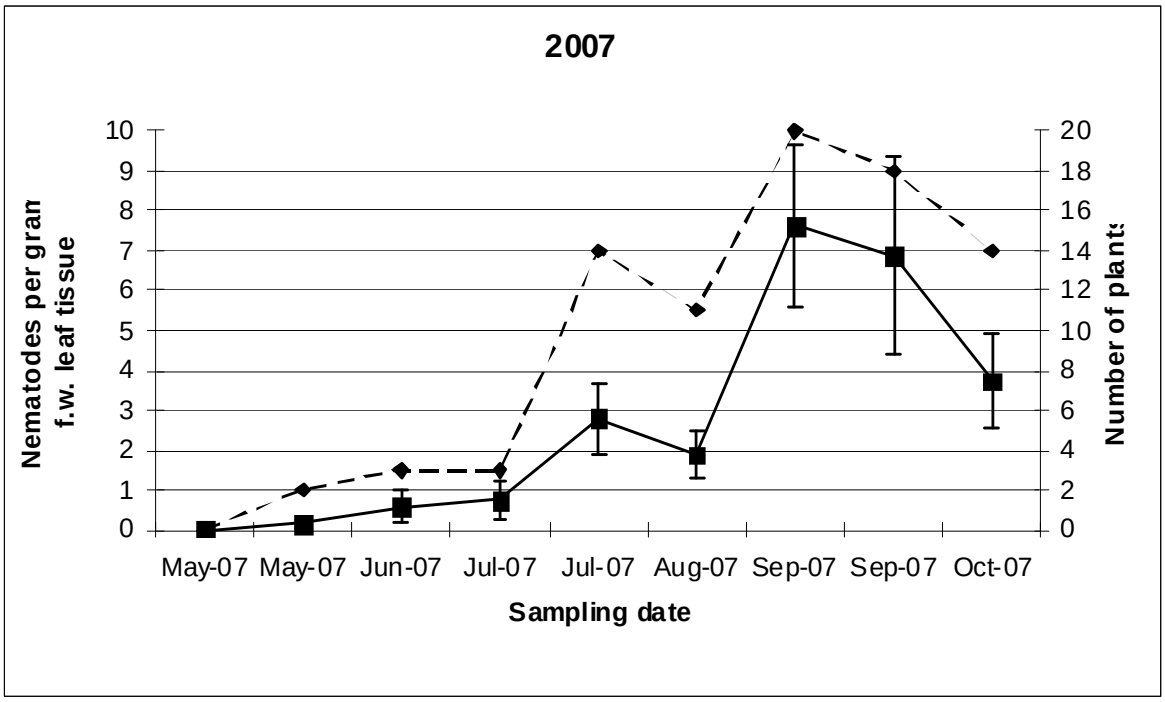
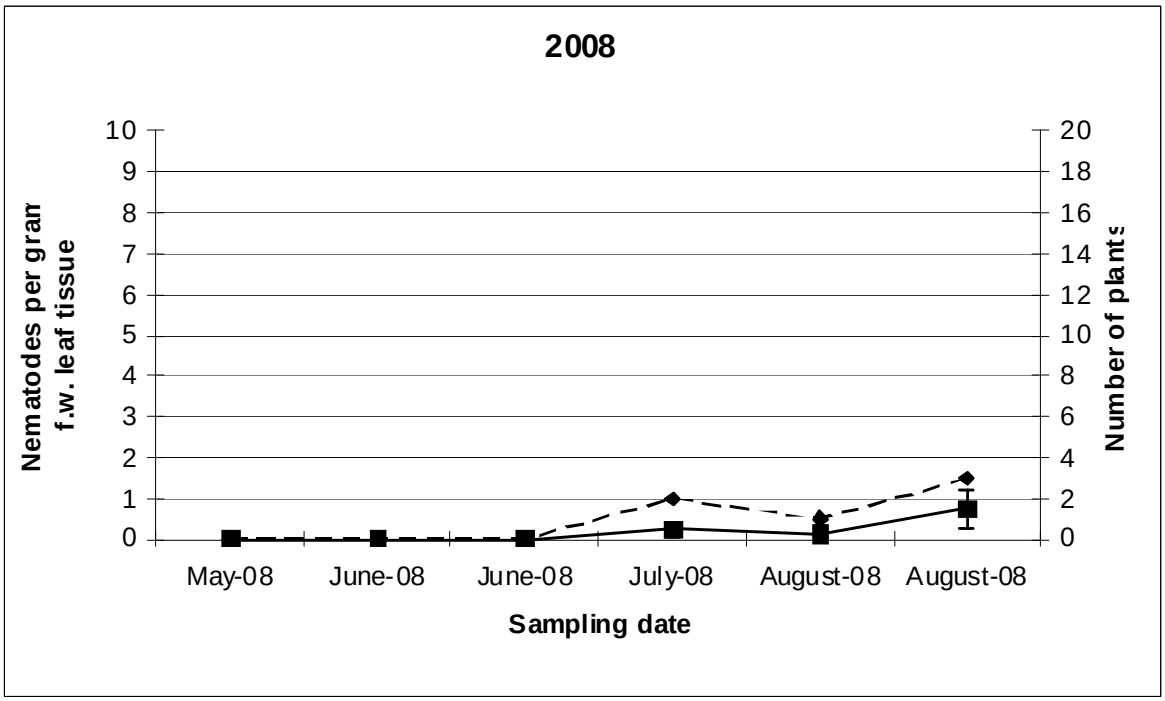

2006
500
400
300
200
100
0
Jun-06
Jun-06
Jul-06
Jul-06
Aug-06
Aug-06
Sep-06
Sep-06
2007
500
400
300
200
100
0
14
12
10
8
6
4
2
0
May-07
May-07
Jun-07
Jul-07
Jul-07
Aug-07
Sep-07
Sep-07
Oct-07
2008
500
400
300
200
100
0
14
12
10
8
6
4
2
-
May-08
Jun-08
Jun-08
Jul-08
Aug-08
Aug-08
Nematodes per gram fresh weight leaf tissue
Symptomatic leaf tissue (%)
Sampling date

FIG. 3. *Aphelenchoides fragariae* counts per gram of fresh weight leaf tissue from asymptomatic leaves of lantana (solid line), and the number of plants at each sampling date from a total of thirty plants that had infected asymptomatic leaves (dashed line). Nematode counts at each sampling date represent the average number of nematodes counted per gram of leaf tissue from six asymptomatic leaves sampled per plant from the middle and bottom tiers of 30 lantana plants grown in containers at a commercial nursery.


2007
Nematodes per gram f.w. leaf tissue
Number of plants
0
1
2
3
4
5
6
7
8
9
10
0
2
4
6
8
10
12
14
16
18
20
May-07
May-07
Jun-07
Jul-07
Jul-07
Aug-07
Sep-07
Sep-07
Oct-07
Sampling date


2008
Nematodes per gram f.w. leaf tissue
Number of plants
0
1
2
3
4
5
6
7
8
9
10
0
2
4
6
8
10
12
14
16
18
20
May-08
June-08
June-08
July-08
August-08
August-08
Sampling date

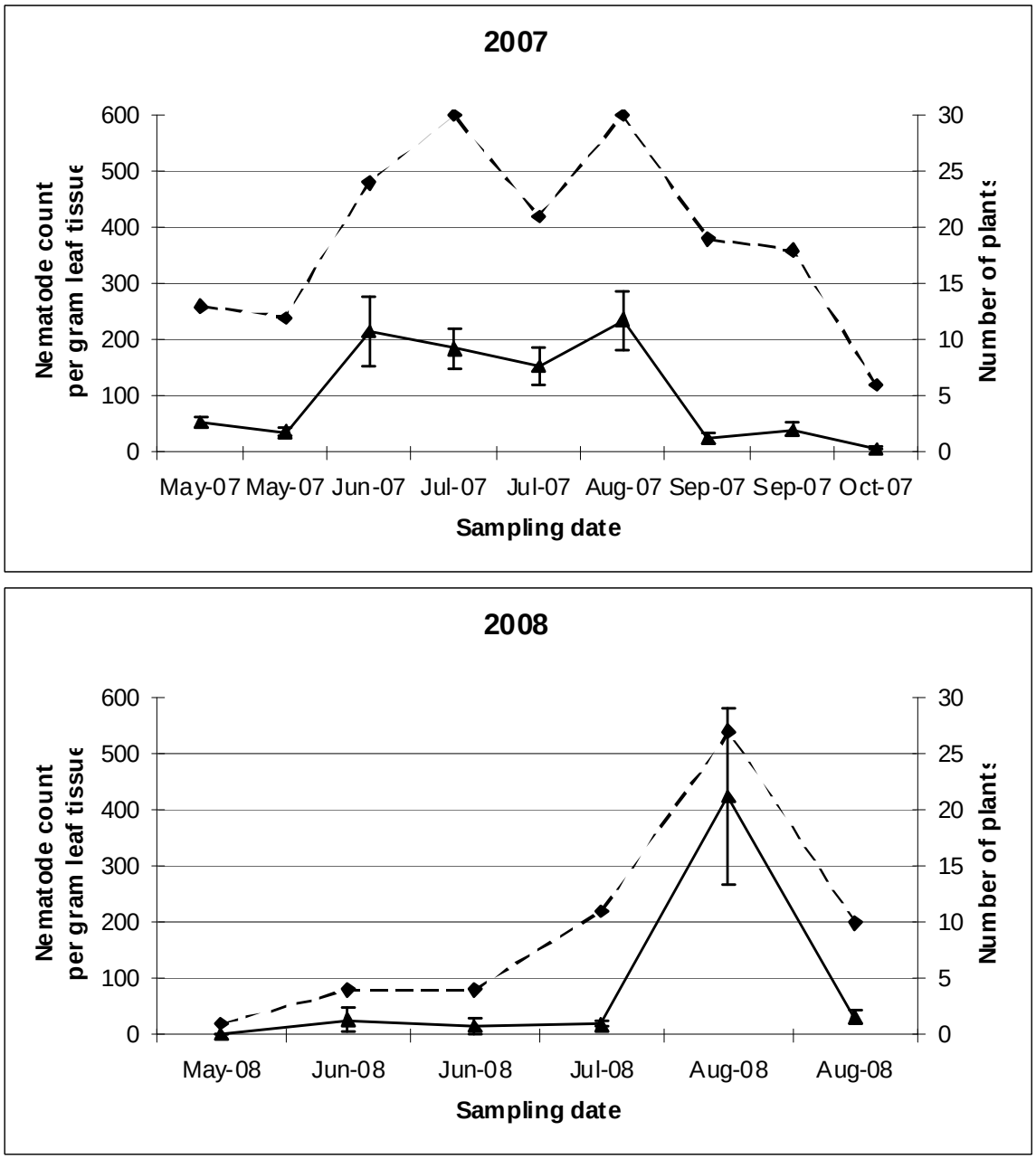


FIG. 4. *Aphelenchoides fragariae* counts per gram of leaf tissue from defoliated leaves collected from the surface of lantana plant containers (solid line), and the number of plants at each sampling date that had defoliated leaves infected with *Aphelenchoides* (dashed line). Two to four defoliated leaves were sampled per plant from 30 lantana plants grown in a commercial nursery.

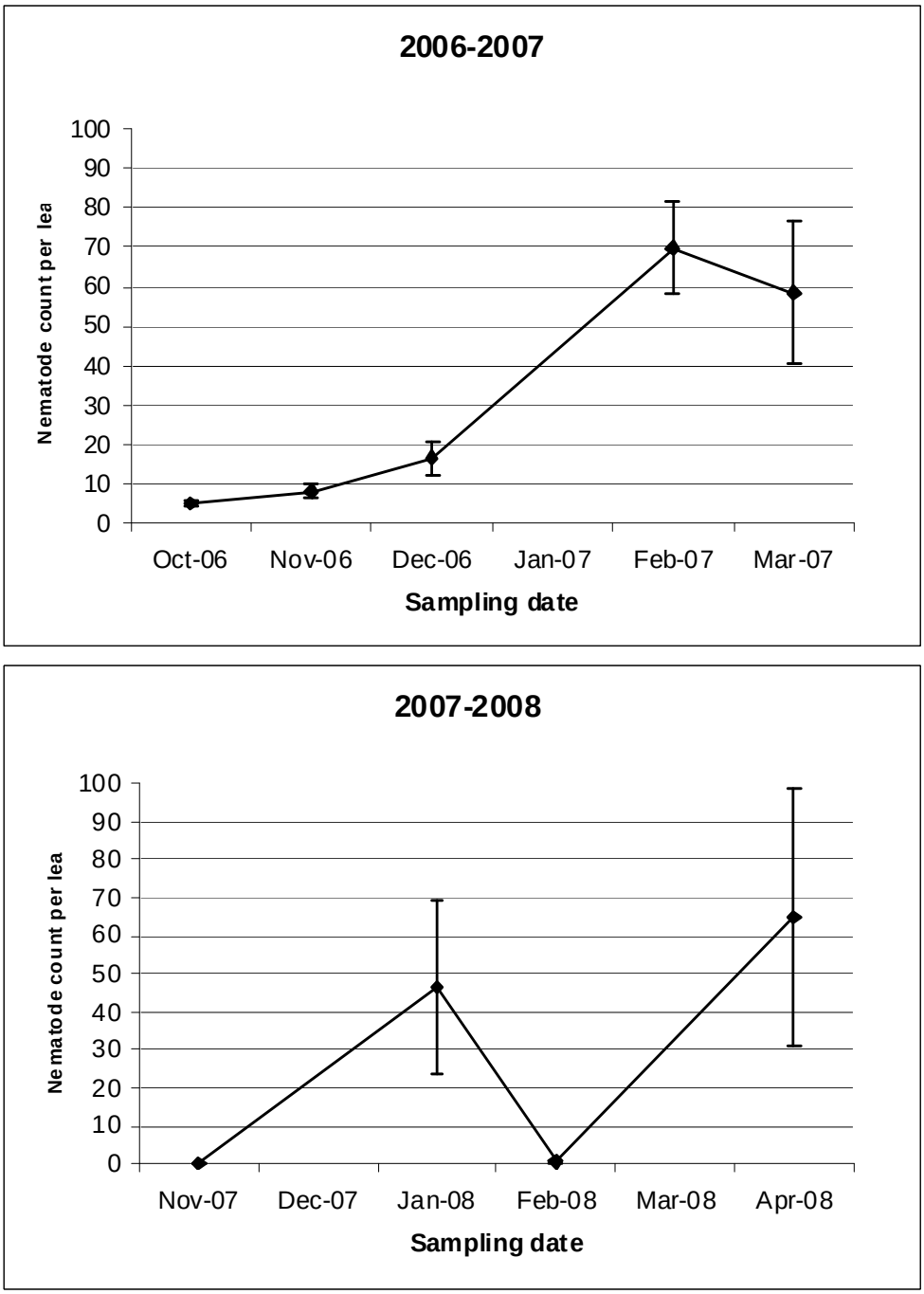


FIG. 5. *Aphelenchoides fragariae* counts per symptomatic leaf sampled. Leaf samples were collected from 30 infected lantana plants in polyhouses during the 2006-7 and 2007-8 overwintering periods.

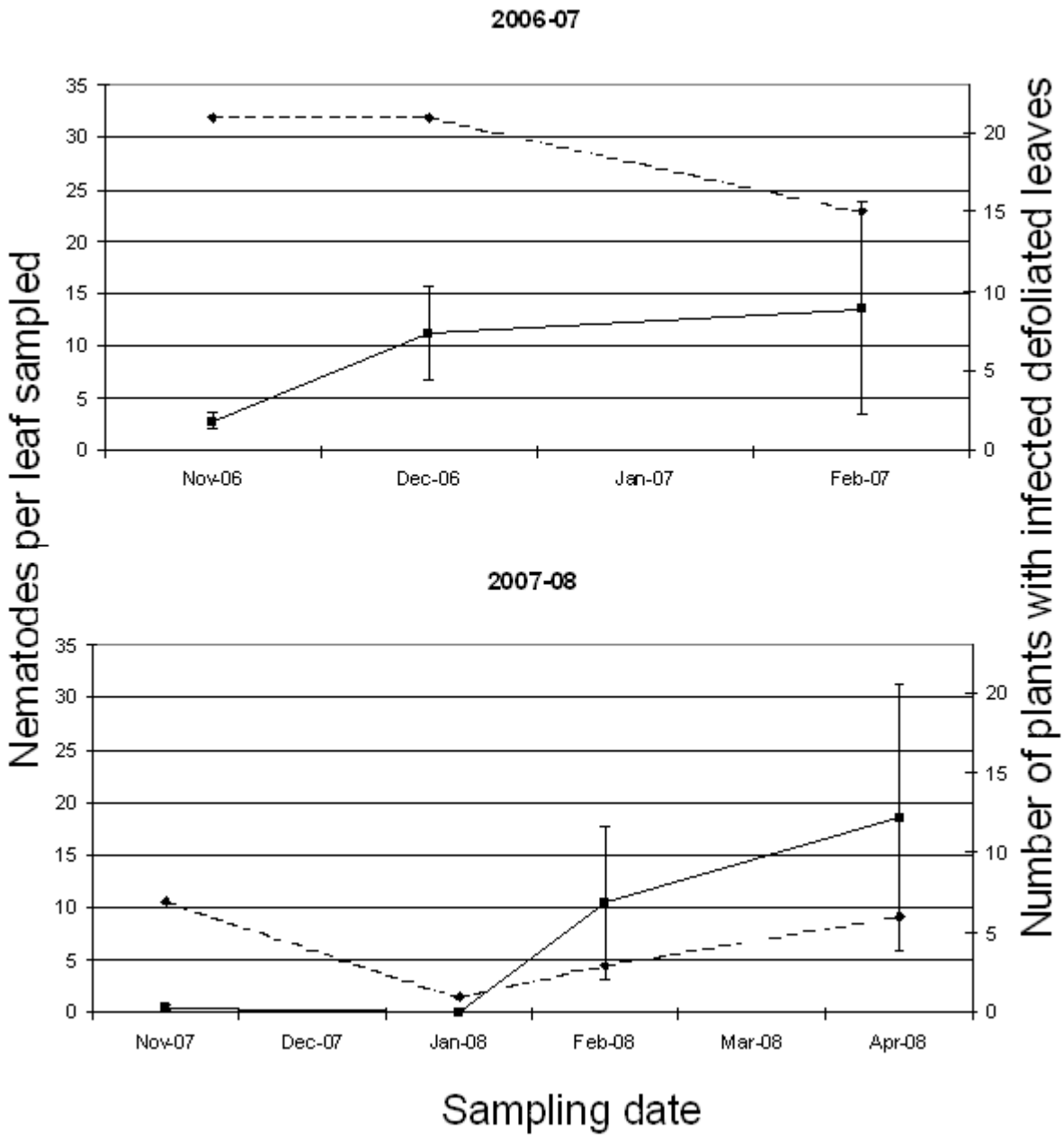
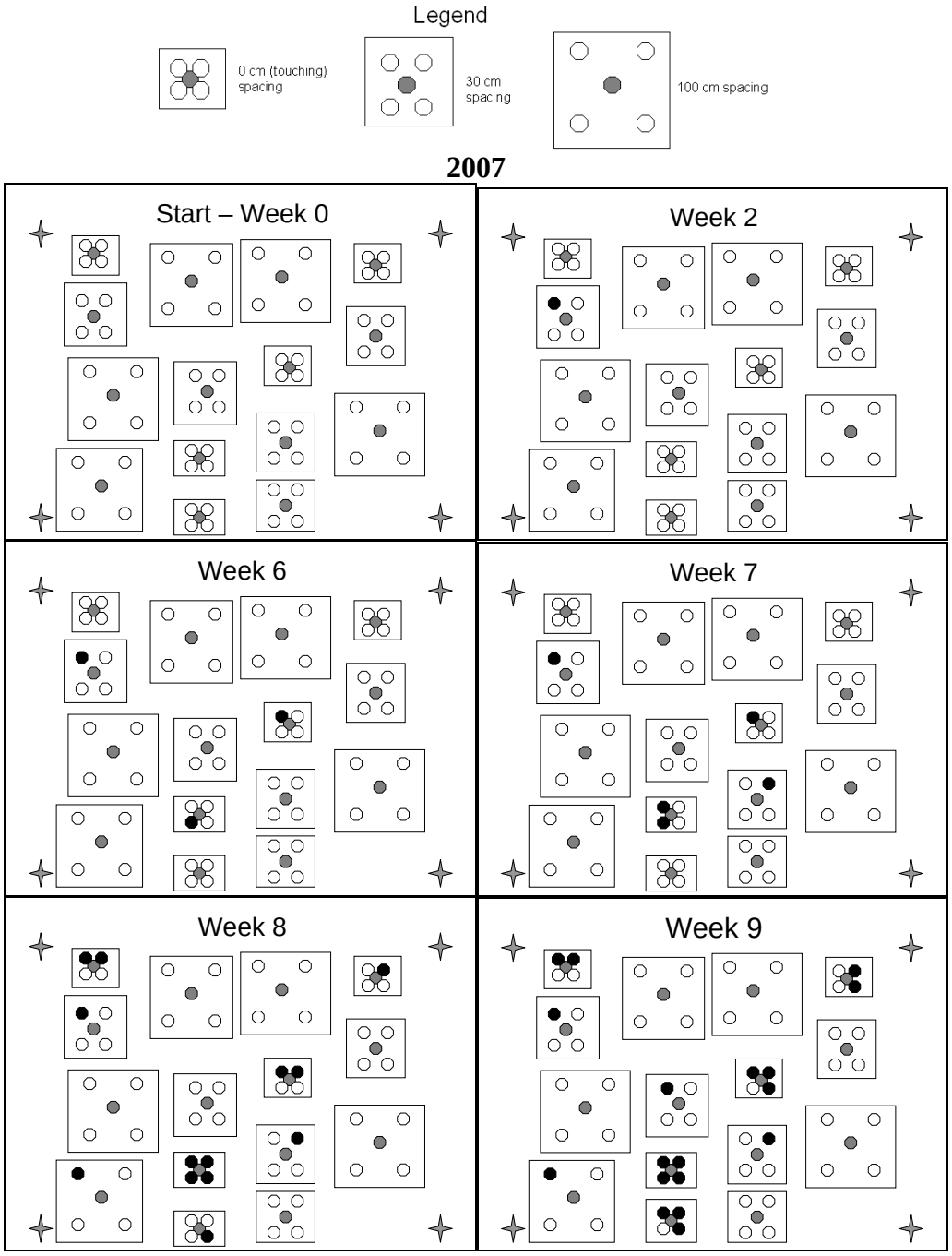
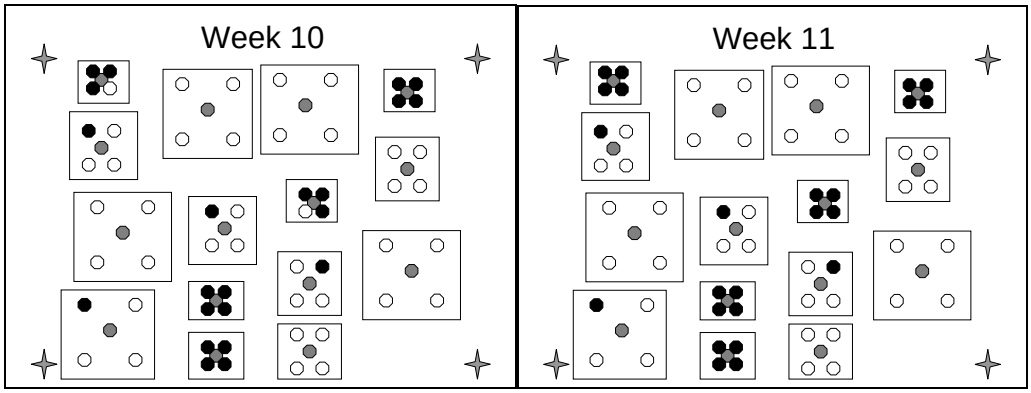


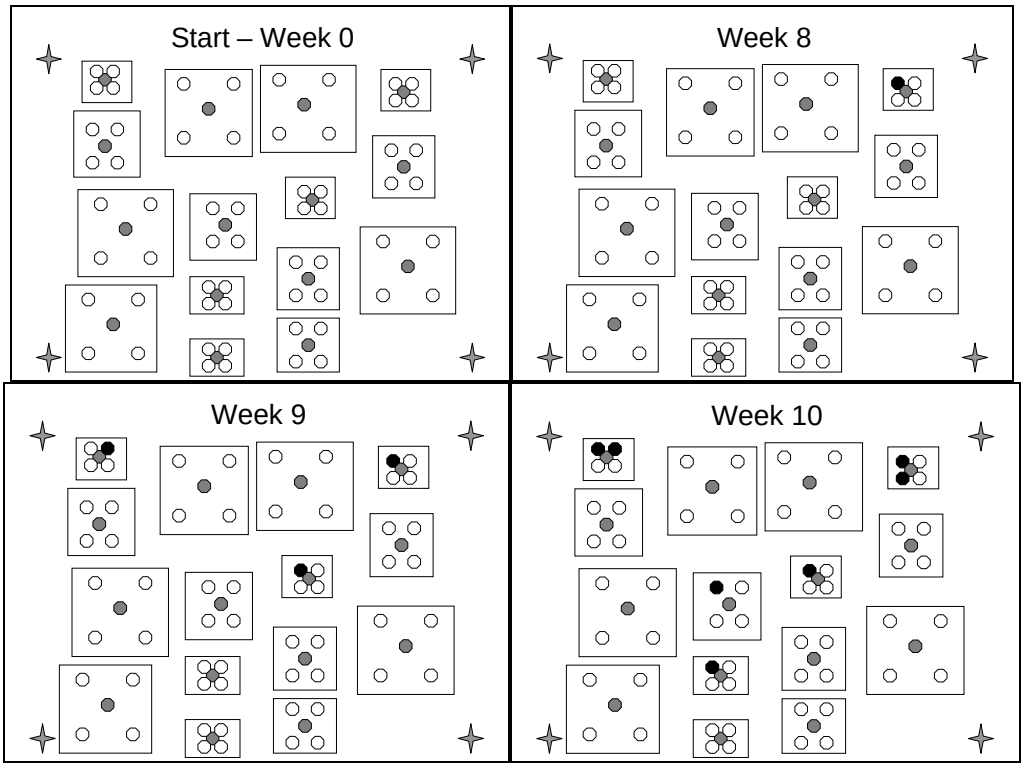
FIG. 6. *Aphelenchoides fragariae* counts per defoliated leaf sampled from container surfaces of 30 infected lantana plants in polyhouses during the 2006-7 and 2007-8 overwintering periods (solid line) and the number of plants that had infected defoliated leaves at each sampling date (dashed line).

FIG. 7. Dispersal pattern of *Aphelenchoides fragariae* at the Horticultural Field Lab, North Carolina State University, Raleigh under daily overhead irrigation during August to October 2007 and July to October 2008. White circles indicate healthy lantana plants, grey circles indicate initially infected plants placed as sources of inoculum, and black circles are lantana plants that became infected during the growing season. Three plant canopy spacings were tested: 0, 30 and 100 cm distance from an infected central plant represented by the three different sized rectangles in the map. There were five replications for each distance. Stars represent the position of the sprinklers.


Legend
0 cm (touching) spacing
30 cm spacing
100 cm spacing
2007
Start – Week 0
Week 2
Week 6
Week 7
Week 8
Week 9



2008



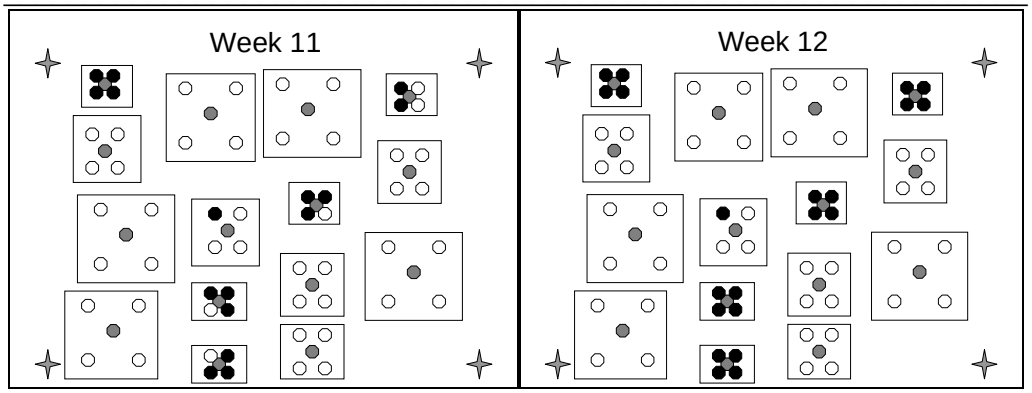
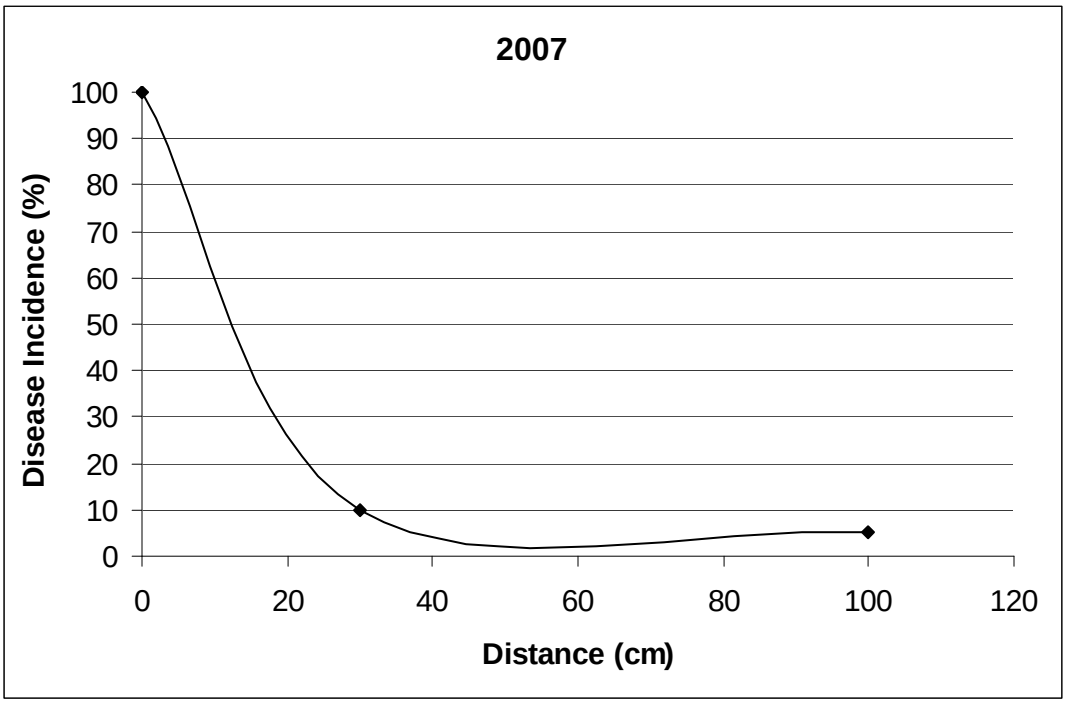
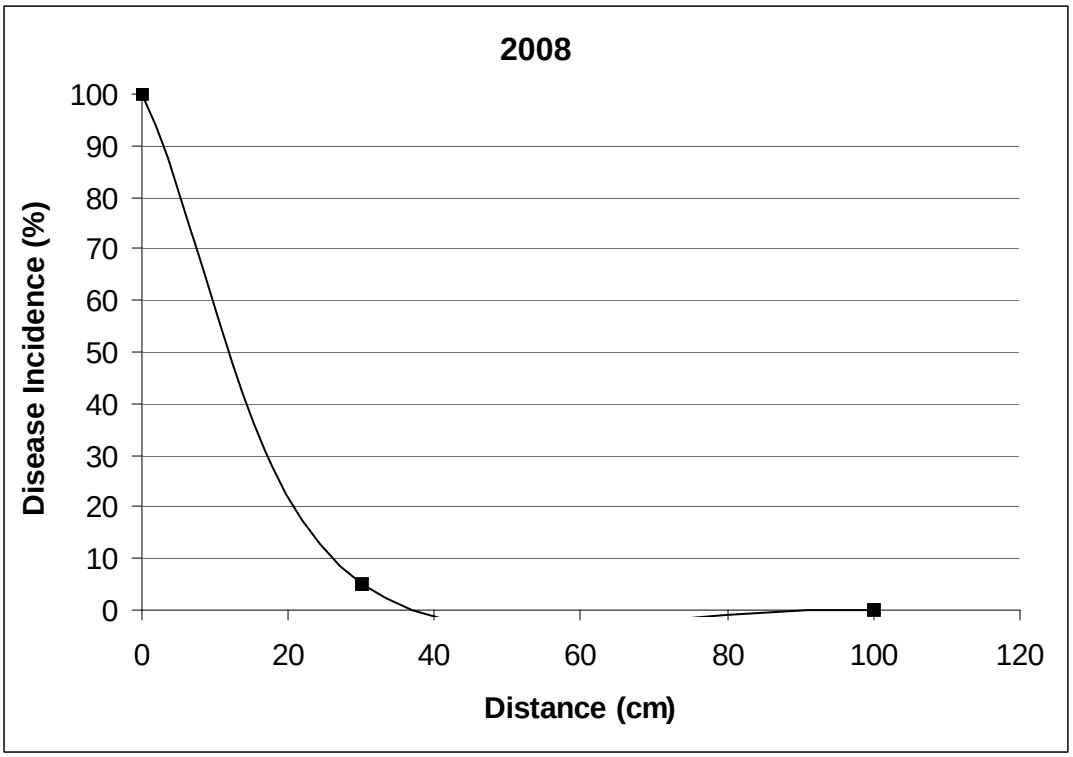

Week 11
Week 12

FIG 8. Dispersal gradient of *Aphelenchoides fragariae* at the Horticultural Field Lab, North Carolina State University, Raleigh under overhead irrigation during the 2007 and 2008 growing seasons.


2007
Disease Incidence (%)
100
90
80
70
60
50
40
30
20
10
0
0
20
40
60
80
100
120
Distance (cm)


2008
Disease Incidence (%)
100
90
80
70
60
50
40
30
20
10
0
0
20
40
60
80
100
120
Distance (cm)