NOTE

Repellency Effects of Garlic Extracts on Twospotted Spider Mite, *Tetranychus urticae* Koch[1,2]

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We evaluated garlic extracts and hot pepper wax as potential repellent sprays in laboratory and greenhouse settings. Boyd and Alverson (1997. Proc. So. Nurserymen's Assoc. Res. Conf. 42: 48-51) showed that Garlic Barrier Ag® (Allium Associates, Bokeelia, FL) was repellent to spider mites at a 100% concentration and that garlic mixtures with fish emulsion were repellent at concentrations ranging from 100% to 10%.

In laboratory experiments the garlic extract used was an organic spray recipe modified from that given by Riotte (1975. Secrets of Companion Planting. Garden Way Publ., Charlotte, VT) as a repellent spray for spider mites and other arthropod pests. Sixty ml of mineral oil was added to 125 g of garlic powder and allowed to adsorb for 24 h. The garlic powder-oil mixture was added to a solution of 500 ml water and 15 ml fish emulsion, stirred, and filtered through cheese cloth. The garlic mixture was used in concentrations (v/v) of 10%, 6%, 4%, and 2% with fish emulsion as the control because fish emulsion was part of the recipe and we were testing the effects of the garlic. Mature lima bean (*Phaseolus lunatus* L.) leaves, attached to the plant, were dipped, one each into each concentration and allowed to dry for 2 h. The leaves were then detached from the plant and placed on thin layers of cotton saturated with water in Petri dishes (100 × 15 mm). A modification of a thumbtack bioassay developed by Weston and Snyder (1990. J. Econ. Entomol. 83: 500-504) and later used by Guo et al. (1993. J. Chem. Ecol. 19: 2965-2979) was used to assess the efficacy of repellent mixtures. An untreated leaf disc (14 mm diam) cut from the center of another leaf of the same maturity from the same plant, was positioned in the middle of each leaf, and 10 adult female mites were placed on each disc. Mites remaining on the leaf disc were counted at 15 min, 30 min, 45 min, 1 h, 2 h, 3 h, and 4 h. The assays were replicated three times on consecutive days. Data were analyzed using a Fisher's protected LSD (Stat View. 1996. Abacus Concepts, Inc., Berkeley, CA.).

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Table 1. Leaf-disc bioassay of low % garlic concentrations in fish emulsion for repellency of twospotted spider mites on lima bean leaves. Means (±SE) show the number of mites remaining on untreated leaf discs placed on whole treated leaf surfaces at progressive times after drying*

	Time						
Treatment	15 m	30 m	45 m	1 h	2 h	3 h	4 h
Emulsion	5.33 ± 0.33 a	7.00 ± 1.53 a	8.33 ± 1.20 b	8.67 ± 1.33 b	8.67 ± 1.33 b	8.33 ± 1.67 a	8.33 ± 1.67 a
10%	8.67 ± 0.88 b	7.33 ± 0.33 a	8.00 ± 1.15 ab	8.67 ± 0.88 b	8.00 ± 0.57 ab	7.67 ± 0.67 a	8.00 ± 0.58 a
6%	7.00 ± 0.00 ab	6.00 ± 0.58 a	7.00 ± 0.00 ab	7.00 ± 0.57 ab	6.33 ± 0.67 ab	6.33 ± 0.67 a	6.33 ± 0.67 a
4%	6.00 ± 1.73 ab	6.00 ± 1.15 a	5.00 ± 0.577 a	5.00 ± 1.00 a	5.00 ± 0.57 a	5.67 ± 0.88 a	5.00 ± 1.16 a
2%	6.67 ± 1.20 ab	6.67 ± 0.88 a	6.00 ± 1.52 ab	6.00 ± 1.53 ab	6.00 ± 1.53 ab	6.00 ± 2.00 a	6.00 ± 1.53 a

* Within each column, means followed by the same letter are not significantly different ($P > 0.05$).

Garlic mixtures (v/v) ranging in concentration from 10% to 2%, run against a fish emulsion control, differed ($P = 0.0456$) between the 10% concentration and the control after 15 min (Table 1). This indicated that, initially, the garlic mixture had a repellent effect; whereas, the fish emulsion did not. At 45 min, 1 h, and 2 h with the 4% concentration, the numbers of twospotted spider mites remaining on the untreated leaf disc were lower than that on the fish emulsion control ($P = 0.0475$, 0.0425, and 0.0295, respectively). No significant differences were observed for any of the other treatments. In a 1997 study (unpublished) water treatment using the leaf-disc bioassay showed no repellent effect on mites leaving the disc within the first 15 min, with only 2 mites remaining on the disc placed on a water-treated leaf. The apparent repellency of the garlic mixture is due to either the garlic or the fish emulsion, or both, for the number of mites remaining aggregated on the small leaf disc was at least 5, half the number originally placed on the disc, and greater than expected for these highly mobile arthropods. Therefore, water was included as control in subsequent greenhouse experiments.

An experiment testing repellency of different solutions was conducted at The Mini-Rose Garden (Cross Hill, SC) using the cultivar of miniature rose 'Old Country Charm.' A total of 75 miniature roses was pruned to approximately the same size. Each miniature rose was potted in 7.62-cm pots. Flats, 12 in a 3 × 4 arrangement, were used to hold the roses in proper position. Twenty-one roses were randomly selected and infested with 10 mites each, using a fine point camel hair paint brush. Each subsequent week, mites were added by placing a rose leaflet infested with 20 to 30 mites on each of the 21 previously infested roses. The mites had been reared on lima beans in a greenhouse at Clemson University or on miniature roses in a greenhouse at the Mini-Rose Garden. Remaining plants were randomly assigned to one of six treatments. Each treatment consisted of 3 miniature roses in a row with a rose infested with mites on each side separated by a space of one pot's width. Each treatment was replicated three times. All six treatments in a row of four flats were considered a block, with three blocks. The position of treatments within each block was randomly assigned.

The six treatments were as follows: (1) Hot Pepper Wax™ Insect Repellent (Hot Pepper Wax, Inc., Greenville, PA), (2) Garlic Barrier Ag, (3) garlic mixture, (4) whole fish emulsion control, (5) fish emulsion fertilizer control, and (6) water control. All solutions were made to equal a volume of 500 ml. The Hot Pepper Wax Insect Repellent solution was used as a 4% (v/v) solution by mixing 20 ml of Hot Pepper Wax with 480 ml water. Garlic barrier was also mixed as a 4% (v/v) solution using 20 ml garlic barrier, 8 ml whole fish emulsion, and 472 ml water. Garlic mixture was used as a 4% (v/v) solution using 20 ml garlic mixture with 480 ml water. Whole fish emulsion control was a solution of 8 ml whole fish emulsion with 492 ml water. Fish emulsion control was a solution of 0.6 ml fish emulsion fertilizer with 499.4 ml water. The water control was 500 ml of water. The concentration, 4% v/v, was that recommended on the label of Garlic barrier.

This study was initiated on 27 Aug 1997. At that time, each rose was observed for twospotted spider mites by counting mites on 10 leaves on each plant using a 10× magnifier. No mites were found on any of the roses. Roses in each treatment were sprayed using a 1-liter hand-held pressure sprayer. Both sides of the leaves were sprayed for complete coverage. Plants were placed in position and a polyethylene barrier was placed around the experimental area to protect plants from other contaminants within the greenhouse and to confine the twospotted spider mites within the

Table 2. Comparisons of treatments for efficacy against twospotted spider mites on miniature roses in the greenhouse. Means (±SE) are spider mites/leaf*

	Date						
Treatment**	17 Sep	24 Sep	01 Oct	08 Oct	15 Oct	22 Oct	29 Oct
HPW	0.00 ± 0.00 a	0.06 ± 0.03 ab	0.34 ± 0.22 ab	0.69 ± 0.31 a	1.26 ± 0.31 a	2.46 ± 0.45 a	2.78 ± 0.92 a
GB	0.07 ± 0.07 a	0.02 ± 0.02 a	0.22 ± 0.09 a	1.60 ± 0.73 a	3.27 ± 1.22 b	3.26 ± 1.12 a	3.96 ± 1.44 ab
GM	0.00 ± 0.00 a	0.14 ± 0.12 ab	0.49 ± 0.26 ab	0.40 ± 0.13 a	1.41 ± 0.42 a	3.14 ± 1.04 a	2.76 ± 0.80 a
WFE	0.03 ± 0.02 a	0.06 ± 0.03 ab	0.02 ± 0.02 a	0.74 ± 0.32 a	1.87 ± 0.30 ab	5.03 ± 0.81 a	6.77 ± 1.14 b
FEF	0.09 ± 0.04 a	0.17 ± 0.08 ab	0.14 ± 0.07 a	3.24 ± 2.29 a	1.94 ± 0.57 ab	2.87 ± 1.15 a	4.80 ± 1.16 ab
Water	0.12 ± 0.12 a	0.28 ± 0.14 b	1.06 ± 0.50 b	2.17 ± 0.69 a	2.40 ± 0.44 ab	3.96 ± 0.69 a	4.82 ± 1.06 ab

* Within each column, means followed by the same letter are not significantly different ($P > 0.05$).

** HPW - hot pepper wax, GB - garlic barrier, GM - garlic mixture, WFE - whole fish emulsion, FEF - fish emulsion fertilizer.

area. The frame of the barrier, 2.59 m long by 1.27 m wide by 0.61 m high, was made of 1.27 cm diam PVC pipe. A polyethylene sheet was then placed around the frame, covering only the sides, leaving the top and bottom open.

Roses were watered daily by an overhead watering system used throughout the greenhouse. Mites were counted (10× magnifier) and plants then re-treated on a 7-day schedule beginning 10 Sep 1997 and continuing through 29 Oct 1997. Ten leaves of approximately the same size were randomly selected from each rose to inspect for mites. Mites of all stages were recorded, with the exception of eggs. Data were analyzed using least squares means procedure, blocking by row and by week.

There were no differences in the numbers of mites among treated roses and control roses (Table 2). Although the two treatments that included garlic showed some repellency to spider mites in the lab bioassay, greenhouse studies did not support those results. Reasons for this could include the overhead watering system, which may have washed off repellent solutions, or the relatively high populations of twospotted spider mites in the greenhouse. A high mite population (>5 mites/leaf) developed on roses in the greenhouse over the time period. Nonetheless, even at relatively low greenhouse populations, there was no significant difference of mite counts between treatments.

Garlic and garlic oils have recently been exempted from certain pesticide laws which may cause the popularity of them to increase, not only for arthropod pests, but also for vertebrate pests (Mason and Linz. 1997. Crop Protection 16: 107-108). Anecdotal recommendations should not include twospotted spider mites, however, as none of the extracts tested have been shown efficacious. Garlic may also be effective against other arthropods in certain ways, as demonstrated by Weissling et al. (1997. Can. Entomol. 129: 637-643) under laboratory and field conditions against the pear psylla, *Cacopsylla pyricola* (Foerster). Their research demonstrated that garlic barrier reduced oviposition of the pear psylla in both choice and no-choice tests, but it did not seem to reduce the feeding of the pear psylla. Thibout and Auger (1997. Acta bot. Gallica 144: 419-426) demonstrated that the sulphur compounds in different types of *Allium* sp. repelled insects that are not associated with the plants in nature. Twospotted spider mites have many hosts and have survived on *Allium sativum* for over a week in our laboratory.

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