Kaolin Particle Film Prevents Galling by *Gynaikothrips uzeli*

**David W. Held,** Entomology and Plant Pathology, Auburn University, Auburn, AL 36849; **Corey Wheeler,** Coastal Research and Extension Center, Mississippi State University, Biloxi, MS 39532; and **David W. Boyd, Jr.**, Department of Biology, Bob Jones University, Greenville, SC 29614

Corresponding author: David W. Held. david.held@auburn.edu


**Abstract**

Feeding by *Gynaikothrips uzeli* Zimmerman (Thysanoptera: Phlaeothripidae), a pest thrips, induces galls on the ornamental plant *Ficus benjamina*, which disfigures plants and can facilitate incidental transport of pests. This study evaluated foliar applications of azadirachtin (Azatin XL), bifenthrin (Talstar), or kaolin (Surround WP) to prevent galling in field and laboratory experiments. Azadirachtin did not significantly prevent galling, but kaolin-treated cuttings had 80% reduction in number of galls in laboratory tests, and in the field, kaolin-treated plants had ≥ 74% reduction in number of galls versus unprotected plants. Weekly applications of kaolin provided comparable protection to bifenthrin. Laboratory choice and no-choice tests indicate kaolin is not lethal and adult *G. uzeli* do not avoid kaolin-treated surfaces. Particle film products are an effective alternative to insecticides for preventing leaf galls on weeping fig.

**Introduction**

*Gynaikothrips uzeli* (Phlaeothripidae), an exotic thrips, is established in most southern states and Hawai’i (4,5). Adult *G. uzeli* are large (2.5 to 3.0 mm), dark colored thrips (Fig. 1). *Ficus benjamina* L., the only known host of *G. uzeli*, occurs in landscapes and production (USDA Hardiness Zones 10b to 11), interiorscapes, or as an annual ornamental in northern climates (1). Adult feeding induces a hypertrophied growth of parenchyma cells (8) causing the leaf to permanently fold along the midvein into a gall (Fig. 2). Gall formation is a prerequisite for oviposition (16). Larvae develop in < 15 days inside galls (C. Boyd and D. W. Held, unpublished data) and only adults are found outside the gall. Plants are protected from galling by maintaining a fresh residue of insecticide on foliage especially new growth (3). Products containing bifenthrin are the most efficacious providing 2 to 3 weeks of residual control of adult *G. uzeli* from a single application (3,6). Plant protectants can reduce or prevent insect feeding (13). Azadirachtin, the active ingredient in neem-based insecticides, is widely documented for its antifeedant and developmental effects on insects (13). Pest thrips (mostly *Frankliniella* spp.) in several cropping systems are managed using azadirachtin (10,11). Azadirachtin is not directly toxic to adult thrips (11), but can be repellent (10) or deter oviposition or feeding.
Particle film technology is successfully used for insect and disease management in tree fruit and vegetable crops (2). Particle films, consisting of small-sized mineral (e.g., kaolin clay) elements, can affect insect behavior through contact with treated surfaces or by producing a highly reflective surface (2). There are only a few reports on the efficacy of kaolin against pest thrips (2,14,15). Particle films action against insects may be lethal or nonlethal (i.e., repellency or avoidance of treated plants). Mortality results from ingestion of mineral particles, or desiccation through abrasion of the cuticle or adsorption by the cuticular waxes (2).

This study compared azadirachtin and kaolin to bifenthrin for prevention of gall induction on *F. benjamina* by *G. uzeli* in laboratory and field experiments. Choice and no-choice tests were also conducted.

**Plant Material and Research Facility**

Plants were grown in the outdoor facilities at the Southern Horticultural Laboratory in Poplarville, MS. Weeping fig (*F. benjamina*), with an established population of *G. uzeli*, were grown in 11.4-liter plastic containers in 100% bark media and received daily, manual irrigation applied only to the container media. Additional potted *F. benjamina* similar in size and culture, were maintained without being infested, in a greenhouse facility at the same location. No pesticides were used on either group of plants. Temperature and rainfall were monitored with an on-site weather station (Hobo, Onset Applications, Bourne, MA). Temperature and relative humidity in the laboratory were also recorded.

**Evaluation of Protectants in the Laboratory**

On 25 September 2006, 144 cuttings were harvested from the block of uninfested *F. benjamina*. Each cutting, a shoot with 2 to 3 leaves (5 to 7.5 cm long), was selected to have developing new leaves. The stem of the cutting was inserted through a hole in the lid of a 118-ml cup filled with water (3).

Treatments included azadirachtin (Azatin XL, 3% azadirachtin, OHP, Mainland, PA) at 1.25 ml/liter, kaolin (Surround WP, 95% kaolin, Engelhard Corp., Iselin, NJ) solutions at 6 and 12% (60 and 120 g Surround WP per liter, respectively), and adjuvant (Capsil, Scotts, Marysville, OH) treated controls. Insecticides were mixed with water in glass bottles with 0.94 ml/liter of adjuvant added to each treatment.

Thirty-six cuttings received one of the aforementioned insecticides or control treatments. Solutions containing kaolin were agitation before and during application. Cuttings were sprayed to runoff using a handheld spray nozzle. Separate spray nozzles were used for each product. Cuttings dried within 30 min, after which they were brought into the laboratory.

Six cuttings of each treatment were placed into a plastic tray inside a plastic box (23.4 × 24.1 × 15.2 cm) with a vented lid. Ten infested galls were harvested from the greenhouse colony of *G. uzeli* on weeping fig and placed in each box. Boxes were held in a rearing room with a 14:10 (L:D) photoperiod and average temperature of 24.3°C. The initial experimental design included bifenthrin.
as another treatment. Preliminary results, however, showed all thrips were killed when bifenthrin-treated cuttings were present in the boxes. Three and 7 days after treatment (DAT), percent of cuttings with galls was recorded. Percentages were arcsin square root transformed to correct for heterogeneity of variances then subjected to an analysis of variance (ANOVA) (Statistix 8.1, Analytical Software, Tallahassee, FL), followed by Tukey’s HSD ($P < 0.05$).

Significantly fewer cuttings treated with kaolin had galls than either adjuvant-only or azadirachtin treatments after 3 and 7 days (Table 1; $P < 0.001$). Particle film rates were not significantly different (Table 1).

Table 1. Gall induction on cuttings treated with plant protectants and exposed to G. uzeli in the laboratory.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Rate (product per liter)</th>
<th>Mean percent ($\pm$ SE) of cuttings with galls after:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>3 days</td>
</tr>
<tr>
<td>Adjuvant$^x$</td>
<td>0.94 ml</td>
<td>25 $\pm$ 7.1 a</td>
</tr>
<tr>
<td>Azadirachtin$^y$</td>
<td>1.25 ml</td>
<td>36.1 $\pm$ 10 a</td>
</tr>
<tr>
<td>Kaolin$^z$</td>
<td>60 g</td>
<td>0 b</td>
</tr>
<tr>
<td>Kaolin$^z$</td>
<td>120 g</td>
<td>0 b</td>
</tr>
</tbody>
</table>

$^x$ Capsil, an organosilicone surfactant.

$^y$ Azatin XL

$^z$ Surround WP

Data were arcsin(sqrt) transformed before analysis. Means presented are actual means. Means followed by the same letter were not significantly different (Tukey’s HSD, $P < 0.05$). There were significantly fewer galls on cuttings treated with kaolin than either the control or azadirachtin treatments after 3 and 7 days ($F = 11.72$ and 31.04, respectively; $df = 3, 15; P < 0.001$).

Comparison of Gall Induction on Plants Treated with Kaolin or Bifenthrin under Field Conditions

On 3 October, uninfested, containerized weeping figs, average height 60 cm, were arranged in rows within a block of potted F. benjamina plants infested with G. uzeli. Each row of uninfested plants was between two rows of eight infested weeping figs. Plants were spaced so that foliage of adjacent plants did not touch. On each uninfested plant, three shoots were marked with flagging tape and the number of succulent, developing leaves, most susceptible to galling, was recorded.

Treatments, bifenthrin (12.5 ml/liter) and kaolin (6% solution of Surround WP), with adjuvant were prepared as previously described, with adjuvant in water as the control treatment. On 3 October 2006, treatments were applied to runoff to the entire canopy using a handheld sprayer delivering about 1 liter of product to six plants (replicates). Six of the 12 plants initially treated with kaolin received additional applications every 7 days.

Every 7 days, the flagged shoots were inspected and numbers of galls formed, as well as the number of succulent leaves were recorded. Data from all samples was subjected to a repeated measure ANOVA with the number of susceptible leaves as a covariable. Within each sample, numbers of galls were compared by ANOVA (Statistix 8.1) and means compared using Tukey’s HSD ($P < 0.05$).

Number of succulent leaves was not a significant covariable ($F = 1.24; df = 1; P = 0.26$). Significant treatment effects (ANOVA for repeated measures; $P < 0.001$, $df = 3, 63$) were evident at 7, 14, 21, 28, and 35 DAT ($F = 47.2, 49.3, 66.4, 74.6, and 54.1$, respectively). Bifenthrin-treated plants remained ungalled for 35 days (Fig. 3). Seven DAT, shoots on control (adjuvant only) plants had significantly more galls than treated plants (Tukey’s HSD, $P < 0.05$). Plants
treated weekly with kaolin were not significantly different from plants treated with bifenthrin. The first post-treatment rainfall was 1.27 cm on 16 October. After that, an additional 12.37 cm of rainfall occurred. Both kaolin treatments had comparable numbers of galls until 28 and 35 DAT (Fig. 3).

Fig. 3. Number of gall induced by adult *G. uzeli* on potted weeping fig treated with either kaolin (Surround WP) or bifenthrin (Talstar). At all evaluations, adjuvant-only controls (Capsil) had significantly more galls (Tukey’s HSD). Plants treated weekly with Surround WP were not significantly different from those treated with bifenthrin. Plants treated once with kaolin (Surround 1×) were comparable to those treated weekly at 7, 14, and 21 DAT but statistically different thereafter.

**Laboratory Choice and No-Choice Experiments**

A kaolin solution (6% solution of Surround WP) was prepared in water as previously described in a 500 ml flask with a stopper so it could be agitated. About 100 ml of this solution was poured into a beaker. Immediately after, glass microscope slides (76.2 × 25.4 mm, VWR Scientific, San Francisco, CA) were dipped into the solution then allowed to dry. Ten slides were prepared with the kaolin, and another set of ten slides was similarly treated with distilled water. Glass slides were used because it provided a more uniformly-treated surface than sprayed or dipped foliage. Treated slides dried in about 30 min, then tangle trap (Tanglefoot, Grand Rapids, MI) was used to outline a 24 × 57-mm area in the center of each slide.

Galls were collected from the previously mentioned block of infested weeping fig. Ten adult *G. uzeli* were transferred to each slide using a moistened paint brush. Once infested, slides were held under fluorescent lighting (14:10 L:D) with average temperature and relative humidity of 20.9°C and 30.3%, respectively. Mortality was recorded the following day (about 18 h). Data were analyzed (Statistix 8.1) using a two-sample *t*-test (*P* < 0.05).

Choice experiments were conducted using glass microscope slides. A 6% solution of Surround WP was prepared and transferred to a beaker as before. Ten slides were submerged halfway into the solution with the other side left untreated. Residues dried then tangle trap was used to delineate a 40 × 24-mm area on each slide such that half was covered with a dry residue of kaolin and the other half untreated. Ten thrips were added to each slide as before. Slides with thrips were held under fluorescent lighting (14:10 L:D) with average temperature and relative humidity of 21.7°C and 34.2%, respectively. The position of the thrips on these slides was recorded after 1, 6, and 24 h. Data were analyzed (Statistix 8.1) using a two sample *t*-test for each assessment (1, 6, and 24 h).
In choice tests, thrips did not avoid the kaolin-treated side (Fig. 4, $P > 0.05$). There was no mortality in the choice test, and only 1 and 10% of thrips died in kaolin and water treatments, respectively in the no-choice test. However, 93% of thrips confined on kaolin-treated slides were trapped in the tangle trap barrier versus 9% of thrips on control slides ($t = 22.1, df = 18, P < 0.0001$) in the no-choice test.

Discussion and Recommendations

Foliar applications of particle film significantly reduced gall induction by *G. uzeli* on weeping fig in laboratory and field experiments. Adults and nymphs of the glassy-winged sharpshooter, *Homolodisca coagulata* (Say), avoided foliage of lemon trees treated with a 6% solution of Surround WP in choice and no-choice tests (12). In choice tests, thrips moved frequently between treated and untreated sides. In fact, adults from choice tests examined under the microscope were adorned with the white particles of kaolin on their integument (D. W. Held, personal observations). Most adults on kaolin-treated slides in the no-choice experiment were trapped in the tangle trap barrier and did not fly off the slides. Results of these tests do not support avoidance/repellency or mortality as modes of action of kaolin against adult *G. uzeli*.

Efficacy of kaolin particle films against thrips (14,15) is equivocal. Most published reports with kaolin products against thrips are from vegetable or fruit crops, and not ornamentals (2). In blueberry, significantly fewer thrips (*Frankliniella* spp.) were collected on sticky traps in plots treated with Surround WP than in untreated plots (15). However, abundance of thrips (Thripidae) in cotton was not different in plots treated with Surround WP versus untreated plots (14).
Single or weekly applications of kaolin reduced numbers of galls by 72.9 and 94.1%, respectively, versus unprotected plants. Furthermore, one application was comparable to a fresh residue for 14 days despite increased rainfall. Unprotected, developing foliage may be more important than rainfastness. Adult *G. uzeli* can feed on mature foliage, but only induce developing foliage to fold into a gall (3,16). Developing leaves on plants treated once with kaolin became unprotected (Fig. 5), however, new growth on plants treated with bifenthrin, or weekly with kaolin, was protected. Bifenthrin has 14 to 21 day efficacy against *G. uzeli* in the lab (3), but can protect plants for 35 day or longer (Fig. 3) in the field. Bifenthrin applied to weeping fig causes significant (≥ 70%) mortality of a minute pirate bug predator (*Montandoniola moraguesi*) for 42 DAT (17) supporting the residual activity of bifenthrin observed in this study.

During field days, Green Industry clientele expressed concerns about growth and marketing of kaolin-treated plants. Effects of kaolin particle film on woody and herbaceous crops vary by crop (2). Some fruit crops (i.e., apples) have yield benefits or lower fruit surface temperatures when kaolin is applied (2). Apples treated with kaolin have increased transpiration and photosynthetically-active radiation is transmitted through particle films (2).

*Ficus benjamina* are in production for multiple years depending on the size of the finished product. During production, applications of kaolin every 14 to 21 days would significantly reduce the number of galls. At the end of production, growers could use bifenthrin to maintain protection, but allow irrigation or rainfall to remove the kaolin residue. Bifenthrin protects plants from galling for at least 35 days and kills adults and immatures inside galls (6).

Galls on weeping fig remain until removed or until abscission, and can be inhabited by several inquilines including exotic pests (4,5,16) making management a regulatory concern (5). Use of particle films during production will reduce numbers of galls and may reduce incidental spread of exotic pests inside galls on weeping fig (4,5).

**Acknowledgments**

The authors thank Jennifer Carroll and Darla Pastorek for technical assistance. Thanks to James Spiers (Auburn University) for reviewing an earlier draft of this manuscript. Funding for this work was provided in part by an IR-4 Project grant.

**Literature Cited**