USE OF KAOLIN CLAY FOR DISEASE CONTROL IN GREENHOUSE CUCUMBERS

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Abstract. Greenhouse vegetables have a high value in the marketplace and consequently consumers have a low tolerance for imperfections. Diseases can be a limiting factor in the high temperature and relative humidity environment of a greenhouse. Because greenhouse vegetables are a relatively small pesticide market, there are few chemical compounds labeled for use in greenhouse production. Foliar applications of clays, such as kaolin, have been suggested as a method of reducing fungal diseases by interfering with the ability of the fungus to penetrate the leaf surface. Foliar kaolin sprays and a phosphite foliar fertilizer (Ele-Max) were compared to current standard chemical sprays for control of downy mildew and gummy stem blight on European cucumbers in a commercial greenhouse. Alternative disease treatments were comparable to the conventional spray program in controlling disease. However, Ele-Max-treated plants had significantly lower yields than all other treatments.

Greenhouse vegetables have a high value in the marketplace and consequently consumers have a low tolerance for imperfections. Diseases can be a limiting factor in the high temperature and high relative humidity environment of a greenhouse. For example, greenhouse cucumbers (Cucumis sativus L.) are routinely sprayed weekly to control gummy stem blight (Didymella bryoniae) and downy mildew (Pseudoperonospora cubensis), the most common foliar disease problems. Even with chemical applications, yield can be reduced as much as 30% compared to disease-free plants (Koblegard, pers. comm.). Because greenhouse vegetables represent a relatively small pesticide market, there are few chemical compounds labeled for use in greenhouse production. An effective, inexpensive, method for control of diseases of greenhouse vegetables would reduce losses while limiting the environmental effects of chemical pesticides.

Foliar applications of clays, such as kaolin, as sprays or dusts have been suggested as a method of reducing fungal diseases by interfering with the ability of the pathogen to penetrate the leaf surface. Kaolin is a nonabrasive, nontoxic aluminosilicate (Al\(_2\)Si\(_4\)O\(_{10}\)(OH)\(_2\)) mineral. While much of the previous work has been done on insect pests of tree crops, there have also been reports of successful control of diseases (Knight et al., 2001; Mayer et al., 2001; Puterka et al., 2000). Vegetable trials have included control of powdery mildew on field grown squash in Israel (Marco et al., 1994) and greenhouse cucumbers in Canada (Ehret et al., 2001). In both cases, foliar applications of clay resulted in reduced disease severity, although no yield or cost-comparison information was included. Greenhouse conditions in the southern U.S. present a particular challenge for disease control because of the difficulty in reducing interior humidity levels and the nearly year-round production. Therefore, the efficacy of clays needs to be tested under Florida conditions. The objective of this study was to evaluate the effectiveness of kaolin clay and phosphite foliar fertilizer compared to standard chemical control for the control of downy mildew and gummy stem blight in greenhouse cucumbers in a commercial greenhouse environment.

Materials and Methods

The test was conducted in a fan-ventilated, gutter-connected greenhouse (35 × 192 ft, 8-ft gutter height) with a double-layer polyethylene covering, currently used for commercial cucumber production in southern central Florida. Four, single-plant 180-ft-long rows were divided into eight plots of 50 plants each. The mildew-susceptible cultivar ‘Korinda’ was used for the tests and the test plot was surrounded by the resistant cultivar ‘Logica’ to prevent disease spread to the rest of the house. Seeds were planted in rockwool cubes. Approximately 10 d after seeding (28 Mar. 2002), plants were transplanted into perlite-filled bags, irrigated and fertigated with a drip system. Fertilizer applications, watering schedules, pruning and tying of plants, and harvest, followed commercial practices. Fruit were harvested three to six times per week, once fruit were of harvestable size, through the beginning of July 2002.

The treatments were 1) standard commercial spray practices (Table 1), 2) 0.5% (w:v) kaolin suspension plus 8 oz/100 gal of

Table 1: Fungicides applied to conventional treatment.

<table>
<thead>
<tr>
<th>Date</th>
<th>Material applied</th>
<th>Intended control</th>
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<tbody>
<tr>
<td>4/13</td>
<td>Oxidate(^v)</td>
<td>General fungicide</td>
</tr>
<tr>
<td>4/20</td>
<td>Tospin M(^y)</td>
<td>Gummy stem blight and Alternaria</td>
</tr>
<tr>
<td>4/27</td>
<td>Kocide(^z)</td>
<td>Downy mildew</td>
</tr>
<tr>
<td>5/4</td>
<td>Botran(^y)</td>
<td>Sclerotinia</td>
</tr>
<tr>
<td>5/11</td>
<td>Oxidate</td>
<td>General fungicide</td>
</tr>
<tr>
<td>5/18</td>
<td>Copper Count N(^y)</td>
<td>Downy mildew</td>
</tr>
<tr>
<td>5/25</td>
<td>Tospin M Kocide</td>
<td>Downy mildew</td>
</tr>
</tbody>
</table>

\(^v\)Biosafe Systems, East Medford, NJ.
\(^y\)Cerexagri Inc., Philadelphia, PA.
\(^z\)Griffin L.L.C., Valdosta, GA.
\(^y\)Gowan Co., Yuma, AZ.
\(^y\)Mineral Research & Development, Charlotte, NC.

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the surfactant Joint Venture (Helena Chemical Co., Collierville, TN) sprayed weekly, 3) 1% (w:v) kaolin suspension plus 8 oz/100 gal of the surfactant Joint Venture sprayed weekly, and 4) Ele-Max 0-28-26 (phosphite) (Helena) at 1 qt/100 gal plus 12 oz/100 gal of the surfactant Joint Venture. Because the test site was a commercial production greenhouse, an untreated control was not feasible. The kaolin (Feldspar Corporation, Edgar, Fla.) used was ceramic grade with a particle size (average 1.36 µm) that would allow it to be applied with conventional spray equipment. Initial applications of kaolin were at 1% and 2% levels. However, the 2% kaolin application resulted in an unacceptable deposition of residues on the fruit. Therefore the 2% kaolin application was reduced to 0.5% for the remaining weekly applications. While Ele-Max is labeled as a foliar fertilizer, it is thought to have fungicidal and systemic acquired resistance (SAR) activity for disease control (Chip Koblegard, pers. comm.). Treatment began on 12 Apr. 2002, 2 weeks after transplanting. For ease of application, materials were applied on half rows, resulting in two replicates of each treatment in the test plot. All plots were sprayed with Topsin M (Cerexagri, Inc., Philadelphia, PA) on 20 Apr. 2002 for control of gummy stem blight, and Botran (Gowan Co., Yuma, AZ) on 4 May 2002 for control of Sclerotinia.

No significant differences existed between treatments at any time, based on Duncan’s Multiple Range Test (0.05). WAT - weeks after transplanting. WAT - weeks after transplanting.

Fig. 1. Incidence of downy mildew.

Natural infestations of downy mildew (Pseudoperonospora cubensis) and gummy stem blight (Didymella bryoniae) were present in the greenhouse. Downy mildew is spread by airborne sporangia and greenhouse conditions provide the periods of leaf wetness necessary for infection (Thomas, 1996). Primary symptoms are chlorotic and necrotic lesions on the leaf that can coalesce to cover much of the leaf surface in serious infections. Gummy stem blight can be evident as pycnidia on the stem surface and can affect the leaves and fruit as well (Sitterly and Keinath, 1996). The organism enters the plants at wounds caused by pruning, harvesting, and other operations.

All plots were evaluated weekly for 4 weeks for presence and severity of downy mildew, starting 1 May 2002, 5 weeks after transplanting and shortly after the first symptoms were observed. By this stage in production, the plants had approximately 22 leaves and had been harvested several times. The number and size of downy mildew lesions on each leaf, starting approximately 3 ft above ground level, were noted. Gummy stem blight symptoms were evaluated twice beginning 6 weeks after transplanting, on 10 May and 22 May 2002. The grower tabulated yields, in tubs of fruit per plot, at each harvest. A tub contains approximately 30 fruit.

Disease incidence values were transformed as arcsine square roots for analysis and presented as percentages. Downy mildew results were analyzed as total number of lesions, total number of leaves with lesions, average number of lesions per infected leaf, average number of lesions per infected plant, average number of leaves with lesions per infected plant, and average lesion length. Data was subjected to Analysis of Variance (ANOVA) and mean separation was by Duncan’s Multiple Range test at the 5% level (SAS Institute, Cary, NC).

Results and Discussion

Incidence of downy mildew (percent of plants showing symptoms) was greater than 63% in all treatments and at all evaluation dates (Fig. 1). However, Kaolin and Ele-Max were as effective as conventional treatments in controlling downy mildew. Although not statistically significant, average disease incidence in the Ele-Max treatment 5 weeks after transplant-
ing was 27% lower than that in the conventional spray program. The distribution of disease in 'hot spots' throughout the test area increased the variability of the results. Variation in disease incidence and severity over time were also affected by leaf pruning and topping of branches done for growth control.

The average number of downy mildew lesions per infected plant (Fig. 2) showed a similar pattern to total number of leaves with downy mildew lesions, total number of downy mildew lesions and average number of leaves with downy mildew lesions per infected plant (data not shown). There were no significant differences between treatments for these measures of disease severity. The average number of downy mildew lesions per infected leaf (Fig. 3) and the average downy mildew lesion length (Fig. 4) were also unaffected by treatment.

Gummy stem blight incidence ranged from 6-23% 8 weeks after transplanting and was not evenly distributed throughout the test plot (data not shown). While treatment was not a significant factor in the analysis of variance, replicate was significant.

Yield losses from downy mildew can occur when the number and size of lesions increase to the point that photosynthesis is affected. Although the grower felt that all treatments gave sufficient disease control to maintain expected yields, this could not be measured due to the inability to maintain a disease-free control. Plots treated with Ele-Max had significantly lower yield, based on grower pack-out data, than those treated with conventional sprays or kaolin (Fig. 5), but this does not appear to be attributable to a higher incidence or increased severity of disease. Other SAR compounds have been found to reduce yield of fruiting vegetables under some conditions (Vavrina, pers. comm.).

These initial results suggest that Ele-Max and kaolin offer control of downy mildew equal to that achieved with conventional fungicide treatments. Further work on concentration and timing of application needs to be done, including the benefits of higher concentrations applied before fruit set for early control. Additional testing under controlled environmental conditions and disease inoculation is needed to determine efficacy of these treatments for gummy stem blight.

**Literature Cited**


