Selective Bee Attractants Did Not Improve Cucumber and Watermelon Yield

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Abstract. The effectiveness of two commercial bee attractants, Bee-Scent and Beeline, for enhancing pollination of cucumber (Cucumis sativus L.) and watermelon (Citrullus lanatus (Thunb.) Matsum. & Nakai) was evaluated by counting the number of bee visitations to blossoms of cucumber and watermelon and their effect(s) on fruit quality, yield, and crop profitability. In 1989, Bee-Scent was tested in a commercial pickling cucumber field. In 1990, watermelon plots were sprayed with Bee-Scent and Beeline and compared with a nontreated control. The compounds did not improve bee visitations for either pickling cucumbers or watermelons. There was no significant improvement in cucumber or watermelon yield or monetary returns.

Visitations by honey bees (Apis mellifera L.) can be a limiting factor in commercial production of cucumber, watermelon, and other crops in the Cucurbitaceae (Brett and Sullivan, 1972; McGregor, 1976). In recent years, Varroa (Varroa jacobsoni Oudemans) and tracheal mites (Acarapis woodi Rennie) have caused a reduction in the number of bee colonies available for commercial vegetable production (Ambrose and Dickerson, 1993). Another complicating factor is that blossoms from neighboring weeds, native vegetation, and other commercial crops may be more attractive to honeybees than cucumber or watermelon blossoms (Brett and Sullivan, 1972). If bee activity could be enhanced in a less attractive crop like cucumber or watermelon by using a bee attractant, fruit quality and yield might be improved.

Many commercial cucumber and watermelon growers obtain honey bee hives to ensure pollination for enhanced fruit yield, size, and shape. Extension recommendations in North Carolina suggest two to three strong (25,000 bees/hive) colonies per hectare of cucumbers (Hoopingarner and Wailer, 1993; Hughes et al., 1988) and one hive per hectare of watermelon (McGregor, 1976). Cucumber blossoms require 8 to 10 bee visits for satisfactory fruit set, whereas fruit weight and seed set are increased with 40 to 50 visits (McGregor, 1976). In cucumbers, honey bees exhibit no preference for staminate vs. pistillate flowers (Amaral et al., 1963; Stephen, 1970). Watermelon blossoms require a minimum of eight bee visits for normal fruit development (Adlerz, 1966). Pollination is of particular concern in triploid watermelons because male flowers contain much less pollen than diploid cultivars (Elmstrom and Maynard, 1990). Triploid watermelon hectarage has increased in recent years to account for ≈ 5% of the commercial crop nationally (Elmstrom and Maynard, 1990).

Several bee attractants are available commercially. Some have been reported to work effectively (Elmstrom and Maynard, 1990; MacKenzie, 1991; Mayer et al., 1989), whereas others have been reported to be ineffective (Burgee and Fisher, 1979; Free, 1965; Mayer and Johansen, 1982; Rajotte and Fell, 1982). Bee-Scent and Bee-Scent Plus (Scentry, Buc- keye, Ariz.), liquid formulations containing bee pheromones, were tested on apple (Malus domestics Borkh.), cherry (Prunus avium L.), pear (Pyrus communis L.), and plum (Prunus domestics L.) and increased both the number of foraging bees and fruit set (Mayer et al., 1989). Beelure (Custom Chemicide, Fresno, Calif.), a syrup composed of several sugars, did not increase the attractiveness of apple blossoms to bees (Rajotte and Fell, 1982). Mayer and Johansen (1982) evaluated Beeline (Custom Chemicide, Clovis, Calif.), anise oil, Pollenaid-D (Crop King Chemicals, Yakima, Wash.), and geraniol for their effects on bee activity on apples and pears and found no increase in pollinator activity. Similarly, the use of Beeline on red clover (Trifolium pratense L.) did not increase pollinator activity or seed yield (Burgee and Fisher, 1979). Free (1965) found that spraying apple trees with solutions containing high concentrations of sugar resulted in bees collecting the sugar from the leaves and petals, thus reducing bee activity on the flowers.

Limited bee attractant studies have been reported on vegetables. A preliminary study by Elmstrom and Maynard (1990) suggested that Bee-Scent might improve early and total yield of watermelon and increase seed yield. The objective of this research was to evaluate the effects of two available bee attractants, Bee-Scent and a new formulation of Beeline, on bee activity, and subsequent fruit yield and quality of cucumber and watermelon.

Materials and Methods

Cultural practices and treatments. In early May 1989, a commercial planting of pickling cucumbers was selected to compare the effects of Bee-Scent and a nontreated control on bee visitation and fruit production and quality. Bee-Scent is marketed as an attractant for...
honey bees and contains a sugar-pheromone base, the pheromones being a citral-geraniol mixture. The field was planted near Goldsboro, N. C., (Expt. 1) with 'Calypso'. Row spacing was 1.0 m with a plant population of \( \approx 62,500 \) plants/ha.

In 1990, in addition to the Bee-Scent and the control treatments, Beeline was included as a treatment for watermelon. Beeline is marketed as a feeding attractant and contains proteins, sucrose, lactose, fats, minerals, and vitamins. The study was located in a commercial field of 'Royal Sweet' watermelon near Newton Grove, N.C. (Expt. 2). Row spacing was 2.1 m with in-row spacing of 1.5 m, resulting in a population of \( \approx 3100 \) plants/ha.

The soils in all experiments were predominantly a Norfolk loamy sand (fine loamy siliceous thermic Typic Paleudults). Overhead irrigation was used in both experiments.

**Experiment 1 (cucumber).** Plots measuring 15.2 m\(^2\) were established in a 2-ha field with at least a 61-m buffer between all treatment plots (Fig. 1). On 12 June 1989, five strong beehives were placed at the edge of the field (three on the north side, two on the south side) when most of the cucumber plants in the field had reached anthesis. Bee-Scent was applied to the foliage in the entire treatment block with a pressurized CO\(_2\) backpack sprayer at the recommended rate of 4.7 liters·ha\(^{-1}\) of product with 187 liters water/ha (until runoff from the leaf). Beehives were placed in the field on 12 June. Spray applications were made the next 5 days (13–17 June). For the control, water alone was applied at the same rate (187 liters water/ha). Spray treatments were replicated three times and applied beginning at 0730 HR and completed by 0830 HR (before the time when bees became most active).

**Experiment 2 (watermelon).** Treatment plots measured 0.37 ha (61 m\(^2\)) (Fig. 2) with a minimum 61-m buffer between all treatments. All treatments were replicated four times. The bee attractants were applied using a boom sprayer on 6 June and again on 11 June 1990 to each of the replications. Beeline was applied at the rate of 11.2 kg·ha\(^{-1}\) and Bee-Scent at 5.8 liters·ha\(^{-1}\) (slightly more than recommended rate) of product; both were applied in 187-liters·ha\(^{-1}\) mixtures. The applications on both dates were made beginning at \( \approx 0800 \) HR and completed by 1000 HR on 6 June and by 0900 HR on 11 June. The first application was made \( \approx 4 \) to 5 days after first bloom. Eight colonies of honey bees were positioned throughout the 10-ha watermelon field on the day before first application of Bee-Scent and Beeline. The hives were positioned so that all treatments had similar exposure to bee visits (Fig. 2).

**Honey bee activity.** In both experiments, honey bee activity was determined by selecting six subplots in each treatment plot. Each subplot for the cucumbers contained 3.0 m of plant row in which 10 blossoms within 1 m were selected to record bee visitation. For the watermelons, each subplot contained four watermelon plants. Bee activity was measured by recording bee visits to each subplot for 2 min/hour beginning at 0800 (cucumber)/0900 (watermelon) HR and ending at 1300 (cucumber)/1400 (watermelon) HR. Each bee visit that involved contact with a blossom (male or female) was scored a visit. One bee could be responsible for multiple visits during the 2 min. To ensure uniformity of bee counts, an observer each day was assigned one or two replications that included a Bee-Scent, nontreated, and Beeline (watermelon only) plot. In Expt. 1, bee visitations were recorded 13–17 and 19 and 21 June. Bee activity for watermelon (Expt. 2) was measured by counting bees beginning at 0900 HR and ending at 1400 HR on 6-8 and 11–13 June.

**Harvest.** Cucumber harvest simulated a once-over destructive machine harvest. Fruit were harvested from six 3.3-m subplots in each treatment plot on 23 June when \( \approx 10 \% \) of the fruit were grade 4 size (>51 mm in diameter) as suggested by Miller and Hughes (1969) and Motes (1977). For the watermelons, five 18.6-m\(^2\) subplots in each treatment plot were harvested one time on 7 July. Fruit were counted and grouped according to weight. Melons were categorized according to North Carolina broker standards as large (>11 kg), medium (<11 to 8 kg), small (<8 to 5.5 kg), and culls (<5.5 kg) (P.E. Bunch, personal communication).

The design was a randomized complete
block with three replications for the cucumbers and four for the watermelons. Yield and monetary comparisons among treatments were made using analysis of variance in both experiments. Treatment significance in the watermelon data were separated using least significant differences (LSD) (P ≤ 0.05). A randomized complete-block design with split-plots with time as the split-plot factor was used as a t test to calculate the $z$ between two means when comparing bee activity.

**Results and Discussion**

Bee activity was monitored in Expt. 1 for five consecutive days from 0800 to 1500 hr to determine the time period when bees were most active. Air temperatures ranged from 20 to 34°C during the time when bee activity was monitored. Bee activity was highest between 0900 and 1200 HR, and about equal regardless of treatment. There was less activity before 0900 HR and a dramatic decline in bee activity after 1200 HR (Fig. 3). Flowers began closing as air temperature increased after 1200 HR. These results agree with those of McGregor (1976) and Amaral et al. (1963), who reported bee activity was highest between 0800 and 1200 HR. There was no difference in total or daily bee activity between treated and nontreated plots (data not presented).

**Cucumber.** Machine harvest of cucumbers requires timely and adequate pollination because fruit set must be as uniform as possible to maximize yield. Marketable and total yield and gross dollar returns were not improved with Bee-Scent as compared with the nontreated control (Table 1). Bee-Scent increased bee activity and fruit set in pear, cherry, and apple trees (Mayer et al., 1989). However, the treatment area was much larger in the fruit tree experiments (0.4 ha) than in our cucumber experiment (0.03 ha). Distances (buffers) between our treated and nontreated plots may have been too close to detect treatment effects. Thus, the treatment area was increased to 0.4 ha, and buffer distances between plots were increased for the watermelon experiments.

**Watermelon.** The total (cumulative) visits for each hour for each treatment were obtained by adding visitsations each day after spray application (spray application on 6 days) (Fig. 4). Peak bee activity on watermelon blossoms occurred during the 1000- and 1100- hr intervals and was similar to bee activity on cucumbers with minimal bee activity after 1400 HR (Fig. 3). There were no differences in bee attractiveness between the two test products nor any difference between either test product and the nontreated plots within any day or for the total study.

There were no significant differences among treatments when watermelon fruit size or total yield were compared, the exception being a small difference in the medium fruit size category (8–11 kg) where Bee-Scent had more fruit than Beeline (Table 2). More importantly, there were no differences in yield in the total marketable or in the cull categories. Fewer culls for a treatment would indicate improved fruit quality. This lack of difference may be the result of increased bee visitations or the increased effectiveness of bee visitations in setting fruit.

In summary, our studies did not demonstrate any increase in attractiveness for cucumber or watermelon blossoms to honey bees when plants were treated with either Bee-Scent or Beeline. These results agree with several publications that reported on the use of these attractants with other horticultural crops (Burgett and Fisher, 1979; Mayer and Johansen, 1982; Rajotte and Fell, 1982). In California, G.E. Tolls (personal communication) evaluated Bee-Scent on pickling cucumbers grown for seed production and found no effect on seed yield. Likewise, H.C. Price and J.R. Hobson (personal communication) found no benefit from applying Bee-Scent to commercial pickling cucumber fields in Michigan.

A bee attractant that is effective under a range of environmental conditions could be beneficial to growers, especially since the number of hives has been reduced in recent years and continues to be threatened by the Varroa and tracheal mites (Ambrose and Dickerson, 1993). Placement of honey bee hives next to a field with a blooming cucumber or watermelon crop is critical for reaching full yield potential. In a 1990 survey of North Carolina cucumber growers, only about one-half of the growers who completed the survey indicated they used honey bees as part of their production practices (Toth et al., 1994). Since the bee attractants in these tests were ineffective, it is especially important that growers use production practices that have been proven effective for improved quality and yields.

**Table 1. Pickling cucumber yield and dollar return as affected by Bee-Scent (Expt. 1).**

<table>
<thead>
<tr>
<th>Cucumber</th>
<th>Mg/ha&lt;sup&gt;−1&lt;/sup&gt;</th>
<th>Value (dollars/ha; thousands)&lt;sup&gt;z&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Nontreated</td>
<td>Treated</td>
</tr>
<tr>
<td>1</td>
<td>3.9</td>
<td>2.9</td>
</tr>
<tr>
<td>2</td>
<td>6.9</td>
<td>4.3</td>
</tr>
<tr>
<td>3</td>
<td>5.2</td>
<td>4.3</td>
</tr>
<tr>
<td>4</td>
<td>3.6</td>
<td>3.0</td>
</tr>
<tr>
<td>Total</td>
<td>13.6</td>
<td>11.3</td>
</tr>
<tr>
<td>Marketable</td>
<td>10.0</td>
<td>8.3</td>
</tr>
</tbody>
</table>

<sup>x</sup> Yield and dollar values based on once-over harvest.<br>
<sup>y</sup> Means for each variable within columns were not significantly different at P ≤ 0.05.<br>
<sup>z</sup> Dollar value obtained by assigning the following prices (per 100 kg) for the marketable grades: grade 1 = $34.80; grade 2 = $17.62; grade 3 = $10.57; grade 4 = $0. The pricing system was the one used by the North Carolina-pickling industry for the Spring 1989 crop.

![Fig. 4. Number of bee visits per 2 min per four plants for Bee-Scent, Beeline, and nontreated plots at hourly time intervals for watermelon (Expt. 2); data not collected for 1200-1400 hr interval.](image)

**Table 2. Effect of bee attractants on ‘Royal Sweet’ watermelon yields (Expt. 2).**

<table>
<thead>
<tr>
<th>Fruit yield</th>
<th>Wt/fruit</th>
<th>Marketable&lt;sup&gt;c&lt;/sup&gt;</th>
<th>Total&lt;sup&gt;c&lt;/sup&gt;</th>
<th>Cull&lt;sup&gt;c&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment</td>
<td>no.</td>
<td>kg</td>
<td>no.</td>
<td>kg</td>
</tr>
<tr>
<td>Control</td>
<td>120</td>
<td>31</td>
<td>577</td>
<td>111</td>
</tr>
<tr>
<td>Bee-Scent</td>
<td>133</td>
<td>39</td>
<td>283</td>
<td>54</td>
</tr>
<tr>
<td>Beeline</td>
<td>64</td>
<td>14</td>
<td>588</td>
<td>118</td>
</tr>
</tbody>
</table>

<sup>c</sup> Total marketable fruit includes all fruit ≤ 5.5 kg.<br>
<sup>c</sup> Total fruit includes all cull and marketable fruit.<br>
<sup>c</sup> Cull fruit includes all fruit <5.5 kg.
Literature Cited
Free, J.B. 1965. Attempts to increase pollination by spraying crops with sugar syrup. J. Apicultural Res. 4:61-64.