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Comparing Species of Bees for Controlled Pollination of *Helianthus petiolaris* in Field Cages

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Honey bees, *Apis mellifera,* have been used for several years to pollinate caged plant species maintained at the USDA-ARS North Central Regional Plant Introduction Station (NCRPIS), Ames, Iowa. Because maintaining large numbers of honey bees is expensive and time consuming, we began looking in 1995 for other pollinator species that can be easily managed and less expensive to maintain than *A. mellifera.* One species we tested was the hornfaced bee, *Osmia cornifrons,* a solitary bee imported from Japan in the late 1970s. We also tested a mixture of native bumblebees, *Bombus bimaculatus* and *B. impatiens,* which are native to the U.S. Midwest. These bee species were compared in field cages to determine which would produce the greatest number of seeds/plant on the wild annual sunflower, *Helianthus petiolaris.* After 2 years testing, honey bees consistently produced more seeds/plant than did the other bees tested.

INDEX DESCRIPTORS: hornfaced bee, bumblebee, honey bee, mason bee, *Apis mellifera, Bombus bimaculatus, Bombus impatiens, Helianthus petiolaris,* pollination

Honey bees, *Apis mellifera* L., have been used for several years to pollinate caged plant germplasm maintained at the USDA-ARS North Central Regional Plant Introduction Station (NCRPIS), Ames, Iowa. Cultivated sunflowers, *Helianthus annuus* L., are hand pollinated because most have large heads and are easily manipulated. The wild-type sunflowers are regenerated differently because they have large numbers of very small heads not easily hand-pollinated.

Each growing season the NCRPIS uses 700 to 800 honey bee nucleus hives to pollinate several species of plants in field pollination cages (see Ellis et al. 1981, for a more detailed description of the cages). Maintaining large numbers of honey bees is expensive and time consuming (see Wilson and Abel 1996, for a brief discussion of honey bee costs). In 1995, we began looking for alternative bees that can be easily managed and would be less expensive to maintain. One such bee was the hornfaced bee, *Osmia cornifrons* (Radoszkowski), a solitary bee that was introduced from Japan in 1977 to pollinate orchards in the eastern United States (Batra 1979). Wilson and Abel (1996) established the optimal conditions to maintain *O. cornifrons* for use in field cage pollination and tested their effectiveness for pollination of Brassicaceae (Wilson et al. 1999). We have also tested other germplasm to determine the pollination efficiency of the native bumblebees, *Bombus bimaculatus* Cresson and *B. impatiens* Cresson, which are important natural pollinators found in the Midwest (unpublished data).

This paper discusses our comparison of *O. cornifrons,* honey bees and bumblebees as cage pollinators of wild-type sunflowers.

METHODS

Two *Helianthus petiolaris* ssp. *petiolaris* accessions, PI 586910 and PI 586934, were used to investigate the effectiveness of honey bees, *Osmia* bees, and bumblebees as pollinators of wild-type sunflower. Accessions of this sunflower species usually do not exceed 1.4 m in height (Rogers et al. 1982), which allowed us to use 1.52-m x 1.52-m x 6.08-m pollination cages. Their small stature also reduced the possibility of heads contacting the screen, which provides a means for external pollination and contamination (Collison and Wilson 1985). Both sunflower accessions were planted in 1995 and 1996 at the NCRPIS in Ames, Iowa. Honey bees and hornfaced bees were tested in 1995 and 1996. Bumblebees were evaluated only in 1996. The honey bee treatment was one nucleus hive (about 4,000 worker bees and one queen); the *Osmia* treatment was bees six straws initially (about 48 bees), and at 7- to 14-d intervals additional straws were added until there were 28 straws per cage; and the bumblebee treatment was eight bees initially, and at 7- to 14-day intervals additional worker bees were added until the total per cage was approximately 48 bees. No effort was made to separate the two species of bumblebee. The pollinator treatment plus a control (no pollinator) were arranged in a randomized complete block design with three replications.

The *H. petiolaris* ssp. *petiolaris* seeds were cold-stratified in April at 5°C for 14 days and placed in a 20°:30°C (12 hr dark: 12 hr light) growth chamber until germination. Seedlings were transplanted into 3.81-cm x 3.81-cm × 10.16-cm Rootrainers ® and allowed to grow in the greenhouse for approximately 4 wks. The total number of plants per accession were divided equally among the plots (approximately 10 plants per accession). Plants were transplanted into each plot on 15 June 1995 and 14 June 1996, and prior to flowering a pollination cage was erected over each plot. Pollinators were placed in the cages after half of the plants had at least one open flower.

In 1995, plots were harvested one to three times (25 August–2 October) as individual heads matured. A single harvest for each plot was conducted in 1996 (20 September for PI 586934 and 27 September for PI 586910). Seed was dried at 30°C for approximately 1 wk. It was then threshed, cleaned, blown to remove large debris, and finally hand picked to remove other contaminants and to ensure

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Table 1. Mean number of sunflower seeds per plant in field cages pollinated by three bee species[a]

	PI 586910		PI 586934	
	1995	1996	1995	1996
Honey bees	7708.1a	3746.0a	2979.9a	309.6ab
Mason bees	1768.2b	1659.0ab	1814.2b	631.8a
Bumblebees	—	504.7b	—	291.8ab
Control	7.5c	34.2b	13.7c	9.3b
LSD	2326.0	2373.0	1052.0	511.5

[a]Different letters within a column are significantly different ($p < 0.05$).

high-quality seed. Data were collected for the total number of seed harvested per plot (cage). Data analyses were conducted on a per-plant basis using the ANOVA-2 program of MSTATC (MSTAT Development Team 1989). When the F value for treatments was significant ($p < 0.05$), means were separated with the RANGE program of MSTATC using the least significant difference (LSD) test ($\alpha = 0.05$).

RESULTS

Table 1 shows the data from the 2-yr study. In 1995, tests of honey bees and *Osmia cornifrons* showed that honey bees were responsible for significantly higher production of seeds per plant for both of the sunflower accessions tested. In 1996, honey bees and *O. cornifrons* were statistically equal in production of seeds per plant for accession PI 586910, and all three bees were statistically equal in number of seeds per plant for accession PI 586934, but the highest mean number of seeds per plant was produced in cages using *Osmia* bees. In 1996, cages using bumblebees also were equal to *O. cornifrons* in the number of seed produced per plant for PI 586910.

A factorial analysis for data combined over years indicated that year was not significant for PI 586910, but significant for PI 586934 ($p<0.001$). Because years was not significant for PI 5896910, an ANOVA-2 analysis was conducted on the combined data. For this accession, honey bees produced the most seed per plant.

DISCUSSION

Using *O. cornifrons* during the summer months creates some problems because these bees are poorly adapted to high temperatures. *Osmia* bees are primarily early season pollinators of fruit trees and other early season plants (Batra 1979), and by midsummer, they have provisioned their nests, the eggs have hatched, and the larvae have begun development for the next generation (they are univoltine). In this investigation, the *Osmia* were held at 1° − 2°C until the sunflowers were flowering in midsummer. The *Osmia* bees did pollinate the sunflowers, but they died in about a week and had to be continually replaced. They did not provision nests, and thus we did not get any generation buildup for the next year. They would be more useful during a summer when temperatures are cooler or perhaps in the northern U.S. or Canada where summer temperatures are usually not as warm as in Iowa. The *Osmia* bees have been effectively used at the NCRPIS as pollinators of early season Brassicaceae accessions (Wilson et al. 1999).

Bumblebees forage naturally on sunflowers in the field. We felt they should have performed much better than they did. Even though the numbers we provided were sufficient, the workers were not part of a functional colony and thus were not as efficient as would be expected had they been supporting a queen and her brood. However, we have successfully used field collected bumblebees as pollinators of *Cuphea* spp. in field cages (RLW, unpublished data).

As a result of this study, our recommendation would be to continue using honey bees for caged seed increase of the wild-type sunflowers.

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