Journal of the Iowa Academy of Science: JIAS

Volume 106 | Number Article 3

1999

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Jour. Iowa Acad. Sci. 106(1):1-3, 1999

Comparing Three Bee Species for Controlled Pollination of Selected Brassicaceae

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Pollination of species of Brassicaceae for seed increase at the USDA-ARS North Central Regional Plant Introduction Station (NCRPIS) has been accomplished for several years by using nucleus hives of honey bees, *Apis mellifera* L., in field cages. Brassicaceae are cool season crops that need pollination from late April to early June in the north temperate zone. Overwintered hives of honey bees need time to strengthen (i.e., increase their numbers) and thus it is difficult to make enough nuclei to meet our early season pollinations needs. Purchasing package bees from suppliers in the southern U.S. is an expensive alternative. In this study, three bee species; a solitary bee, *Osmia cornifrons* (Radoszkowski) (Hymenoptera: Megachilidae); honey bees; and alfalfa leafcutting bees, *Megachile rotundata* (Fab) (Hymenoptera: Megachilidae), were compared for their utility as early season pollinators of Brassicaceae species in field cages. *Osmia cornifrons* proved to be equal to or better than leafcutters and honey bees for pollination of Brassicaceae in field cages as measured by seed produced/plant. Future seed increases of Brassicaceae at the NCRPIS will utilize *Osmia cornifrons* in field cages because they are effective pollinators and they are easily managed.

INDEX DESCRIPTORS: hornfaced bee, mason bee, alfalfa leafcutting bee, honey bee, pollination, *Osmia cornifrons, Megachile rotundata, Apis mellifera.*

The United States Department of Agriculture—Agricultural Research Service North Central Regional Plant Introduction Station (NCRPIS) is part of the National Plant Germplasm System (NPGS). The NPGS is a network of Federal and State institutions and research units dedicated to conserving and encouraging the use of germplasm, most commonly in the form of seeds. Many of the crops maintained at the NCRPIS are cross-pollinated which requires some form of controlled pollination to maintain the genetic integrity of the germplasm.

Honey bees, *Apis mellifera* L., have been used at the NCRPIS for controlled cage pollination of Brassicaceae for several years. Nucleus hives containing 4,000–6,000 worker bees and a queen are placed into field cages measuring 6.4 × 1.6 × 1.6 m (Ellis et al. 1981). This technique has been used to pollinate sunflower (*Helianthus* spp.), cucurbits (*Cucurbita* spp.), cuphea (*Cuphea* spp.) and some species of Brassicaceae. In general, plants in the Brassicaceae are early, cool season plants. It is difficult to establish enough pollinating nuclei from overwintered colonies to meet the growing demands for pollinating insects at the NCRPIS. In addition, honey bee management requires considerable labor and cost.

Therefore, honey bees were compared to other non-*Apis* species in earlier studies of pollinating efficiency to determine if there are more efficient ways to pollinate various caged seed increase plots. In many cases, it was found that non-*Apis* species were effective pollinators (Roath et al. 1990; Wilson et al. 1991; Wilson and Roath 1992). This paper reports the results of comparing three species of bees, *Osmia cornifrons,* honey bees, and alfalfa leafcutting bees, *Megachile rotundata* (Fab.), for pollination of selected Brassicaceae in field cages.

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The hornfaced bee, *Osmia cornifrons* (Radoszkowski) (Hymenoptera: Megachilidae), was imported in 1977 from Japan into the eastern United States as an orchard pollinator (Batra 1979). The alfalfa leafcutting bee, a native of southeastern Europe, was accidentally introduced into eastern North America in the 1930s (Eves et al. 1980).

METHODS

Two accessions of *Brassica rapa* (PI 278766 and PI 392025) were planted in 5 × 5 cm peat pots in the greenhouse on 4 March 1994. On 15 April 1994, all surviving plants (about 135 per accession) were equally divided and transplanted into each of 16 field cages measuring 6.4 × 1.6 × 1.6 m. We used a completely randomized block design with treatments as follows: 4 cages (replicates) each received (1) one honey bee nucleus containing 4,000–6,000 worker bees and a queen, (2) alfalfa leafcutting bees (about 250), (3) 6 straws containing about 48 *O. cornifrons,* and (4) an untreated control. Plants were harvested when >50% of the siliques had turned brown (late June to early July). Plants in each cage were counted, threshed, and the seeds obtained were cleaned. Grams of seed obtained were divided by the number of plants per cage to calculate the grams of seed/plant. Data were analyzed using the FACTOR analysis of MSTAT-C (MSTAT Development Team, 1989). When the F-value for treatments was significant ($P < 0.05$), means were separated with the least significant difference (LSD) test ($\alpha = 0.05$) included in the RANGE program of MSTAT-C.

In 1995, two additional PI accessions were added to the test (PI 209022 [*Sinapis alba*] and PI 469944 [*Brassica napus*]). The plants were planted in the greenhouse on the following dates: PI 209022 (20 February 1995), PI 278766 (3 March 1995), PI 392025 (7 March 1995), and PI 469944 (16 February 1995). All were transplanted into field plots from 17–24 April 1995. Experimental design and treatments were the same as in 1994. Plants were harvested when >50% of the siliques had turned brown. PI 209022 was harvested on 17 July 1995, PI 278766 on 11 July 1995, PI 392025

Table 1. Seed per plant for two *Brassica* and one *Sinapis* species pollinated by 3 different bee species, Ames, IA.

	SEED PER PLANT (gm)[a]							
	TREATMENT							
	1994				1995			
ACCESSION	HB[b]	ALC[c]	*OSMIA*[d]	CONTROL	HB	ALC	*OSMIA*	CONTROL
PI 209022	—	—	—	—	3.7a	3.0a	3.5a	1.5b
PI 278766	1.0b	0.6bc	1.6a	0.5c	5.5a	5.8a	6.2a	3.3b
PI 392025	1.2ab	1.4a	1.7a	0.4b	5.9a	6.6a	6.4a	4.9a
PI 469944	—	—	—	—	8.2ab	9.5a	8.0b	8.5ab

[a]Row means followed by the same letter within years are not significantly different according to the LSD test ($P < 0.05$)
[b]Honey bee
[c]Alfalfa leafcutting bee
[d]*Osmia cornifrons*

on 12 July 1995, and PI 467944 from 21–26 July 1995. Seeds were processed as in 1994 and grams of seed/head were calculated. Statistical analysis procedures used in 1994 were repeated.

RESULTS

During 1994, *Osmia cornifrons* produced significantly more seed/head on PI 278766 than did the other bees. There was no difference between the bees for seed produced/head on PI 392025 (Table 1).

In 1995, *Osmia cornifrons* was equal to the other bees in the amount of seed produced/plant for 3 of the accessions tested. PI 469944 was the exception. According to Free (1993), *Brassica napus* are highly self-pollinating plants and this is evidenced by the seed produced in the no-bee control cages.

DISCUSSION

Even though *Osmia cornifrons* did not produce significantly more seed than the other bees for most of the accessions tested, these bees are easier to manage than honey bees and less costly to use than are honey bees and alfalfa leafcutting bees. Consequently, we plan to increase our use of this species in seed regeneration program at NCRPIS.

A summary of the cost of managing the three species of bees is given in Table 2.

Observation of honey bees in cages showed them to be less effective as an early-season pollinator when the weather was damp and cool. *Osmia* bees were observed to collect pollen and place it on their abdominal scopa in a dry state, whereas honey bees will wet and pack the pollen when they load their hind tibia scopa. Also, while visiting flowers, the *Osmia* maintained consistent contact with the stigma and anthers. Honey bees landed on the petals when searching for nectar and didn't come in contact with the stigma. When honey bees were searching for pollen, they effectively harvested pollen which made less available for pollination. On the average, honey bees spent 3.8 seconds/flower visit (15 observations) while *Osmia* spent 1.5 seconds/flower visit (15 observations). Thus, the *Osmia* will come in contact with many more flowers than will honey bees.

Alfalfa leafcutting bees are relatively inexpensive but must be imported from Canada each year. *Osmia cornifrons* can be increased in the field locally and stored until needed (Wilson and Abel, 1996). In the future, the NCRPIS plans to use *O. cornifrons* as exclusive pollinators of Brassicaceae accessions in field cage multiplication plots.

Table 2. A summary of costs associated with managing three species of bees.

BEE	BEE COST/ CAGE	LABOR COSTS/ CAGE	TOTAL COST/ CAGE
Hornfaced bee (*Osmia cornifrons*)	$ 3.84[a]	$3.00[b]	$ 6.84
Honey bee (*Apis mellifera*)	$37.30[c]	$6.00[d]	$43.30
Alfalfa leafcutting bee (*Megachile rotundata*)	$ 0.80[e]	$4.00[f]	$ 4.80

[a]48 bees/cage @ $0.08/bee
[b]15 min/cage @ $12.00/hr
[c]One 2-lb package/cage @ $31.50/package (includes shipping); bee food costs for corn syrup @ $1.90/gal and pollen @ $2.00
[d]30 min/cage @ $12.00/hr
[e]250 bees/cage
[f]20 min/cage @ $12.00/hr

ACKNOWLEDGMENTS

The authors wish to thank Nate Bye, Brett Roberts, and Ron Schweppe for help in manipulating the bees. This article is a joint contribution from the USDA-ARS and the Departments of Agronomy and Entomology, Iowa State University. This is Journal Paper No. J-17642 of the Iowa Agricultural and Home Economics Experiment Station, Ames, Iowa, Project No. 1018, and supported by Hatch Act and State of Iowa funds.

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