A Novel Use for Bees: Controlled Pollination of Germplasm Collections

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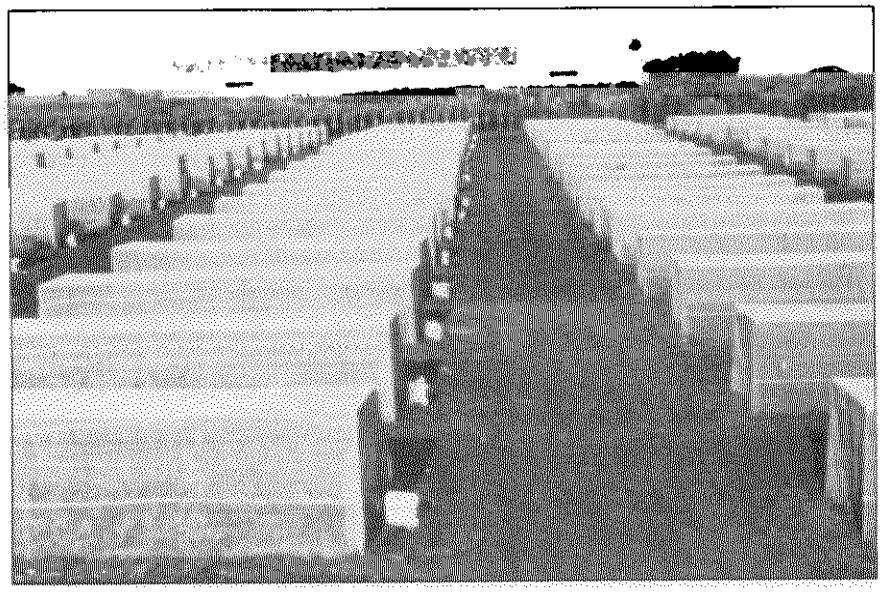
Most people in Iowa are not aware of it, but during the spring and summer about 1,000 colonies of honey bees are located on a farm owned by Iowa State University on the south side of Ames, Iowa. These bees are not here for honey production, or even crop pollination in the traditional use of the term. As you drive by on four-lane highway 30, you see row after row of field cages covering small plots of growing plants. Each of these cages is stocked with bees to pollinate special varieties of plants that are grown from seed being stored at the USDA facility located on the property.

The facility is called the North Central Regional Plant Introduction Station (NCRPIS). NCRPIS is one of four regional centers in the country. Established in 1948, NCRPIS (known locally as "the PI Station") exists for the purpose of conserving and encouraging the use of valuable collections of plant germplasm. Plant germplasm is living tissue (usually seeds) from which new plants can be grown. The germplasm maintained by the PI Station for each crop species is genetically diverse. This genetic diversity is used by researchers to develop improved varieties of crops. Plant germplasm is an invaluable resource to our nation's agriculture.

At the PI Station, when seed supplies become low or germination percentages fall below predetermined levels, a seed lot is taken out of storage, planted, and new seed produced and stored. Great care must be taken to maintain the genetic integrity of the plant population. For plants benefitting from insect pollination, this is done by placing insect-proof field cages over the plants. The cages exclude pollinating insects from transferring pollen from one variety to another. To pollinate the plant population growing under the cage, an insect pollinator is provided within. Honey bees have been the primary pollinating insects used.

For years the former PI Station farm manager, Herb Spencer, was responsible for maintaining bee colonies along with his other numerous duties that went along with being a farm manager. However, in 1986, a new position was created for a beekeeper to care for the bees full-time. Craig Abel has filled this position since 1987. Initially, only honey bee colonies were used and these were started each spring from packages. However, since then the management strategy has been drastically changed.

Pollinating colonies are kept in six-frame medium depth (6 5/8") boxes. This size works best for their field cages (dimensions are 24'x5'x4' high). Colonies do not have enough forage



Field cages at the PI Station in Ames for controlled pollination of different plant populations

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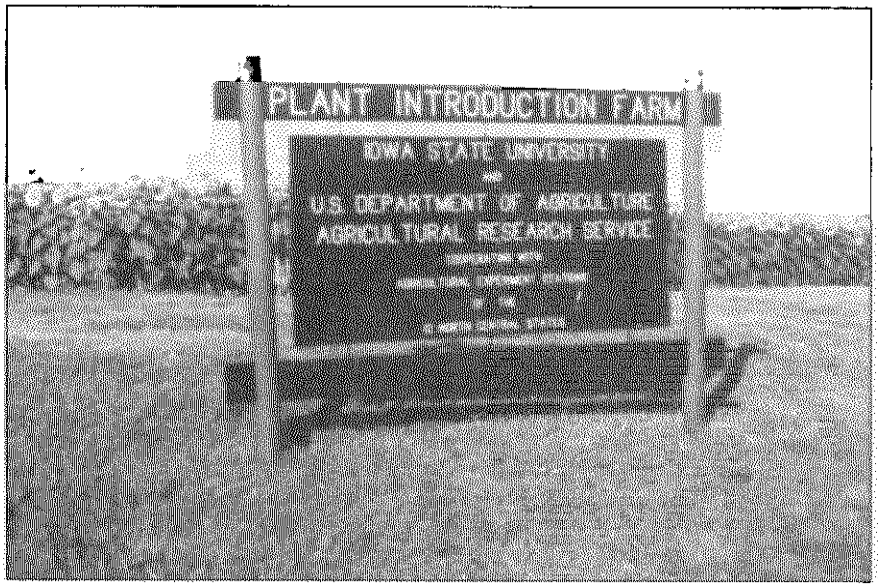
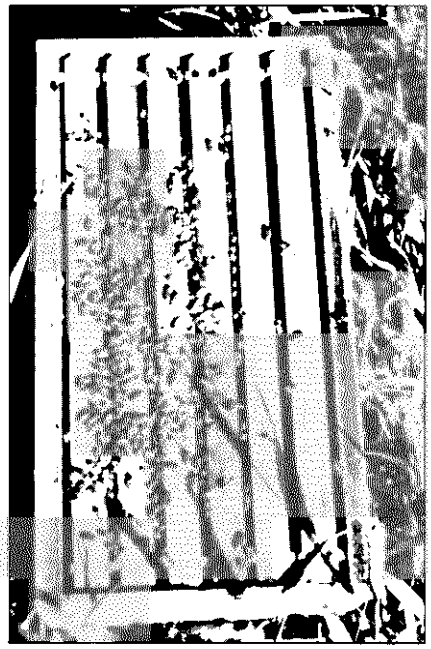


Plant Introduction Station entrance with sunflowers in background



Pollinating nucleus colony housed in a six-frame medium depth box.

Seed storage room- About 1,100 plant species containing 40,000 accessions or plant populations are maintained at the PI Station in Ames.

Melons, cucumbers & other vegetables	500 cages
Canola (*Brassica spp.* - rape)	200 cages
Sunflower (*Helianthus spp.*)	150 cages
Cuphea (an experimental oil seed crop)	50 cages
Ornamentals	50 cages
Miscellaneous plants requiring controlled pollination	50 cages
Pumpkins	hand-pollinated, no cages
Corn	hand-pollinated, no cages
Other crop species	not requiring controlled pollination, no cages

available in that size plot, so colonies are fed high fructose corn syrup and pollen/pollen substitute cakes continually while in the cage. Colonies straddle the wall of the cage so that bees can be excluded from the cage and allowed to fly outside if the plants in the cage need to be sprayed with pesticides.

The table shows some of the crops that are pollinated and the number of cages of each. In all, 1,100 plant species containing 40,000 accessions or plant populations are maintained at the PI Station in Ames.

Placing a colony of bees in a small field cage for up to three months stresses it. Consequently, most of the colonies will not overwinter, even if combined with other weak colonies. As we all experienced this year, package bees are expensive and not always available when we want them. Craig found that if they kept breeder stock outside the cages from which to rear queens and make up small nucleus colonies, they could cut their costs per cage for pollination services. Additionally, they could become more self-sufficient and slow the introduction of exotic bee pests into their bee population. Starting in May they now produce queen cells by the grafting technique to have ready for starting nucs. Each nuc gets three frames of brood and adult bees, one ripe queen cell, two frames of honey and a frame of pollen, if they can find enough of them.

When the parasitic mites became established in the area, Craig found that overwintering bees in the cold Iowa winter environment became increasingly difficult. As a result, they converted a dou-

Craig Abel, PI Station beekeeper with a nucleus colony in cage with Canola plants growing inside

Alfalfa leaf-cutter bee (*Megachile rotundata*) loose cells.

ble-garage into an environmentally controlled room (dimensions are 24'x20') where they could overwinter bees indoors. This room is kept dark and at about 40ºF +/-2ºF with thermostatically-controlled ventilation fans, heaters and an air conditioner. This room will hold 325 colonies consisting of two medium depth boxes each. This winter ('95/'96) they lost only two out of 167 parent colonies put away for winter. Additionally, they were able to overwinter 35% of the small pollinating nuclei. This management strategy has further reduced the cost of the pollinating units.

In order to further streamline the pollination process, Craig began to look at alternate pollinators among non-honeybee species. These new pollinators had to be manageable and pollinate as well as honey bees in the cages. If the new bee was also less expensive, then they would use them instead of honey bees to pollinate a particular crop.

Alfalfa leaf-cutter bees (*Megachile rotundata*) are well known as an alternate pollinator and were tried experimentally at the farm. The advantage of these bees is their relatively low cost ($200/gallon) and they are easy to rear and readily available. The bees are sold as loose cells by the gallon (containing about 12,000 cells/gallon). About 100 cells are used in each cage. Each cell is a little cocoon covered with leaf pieces containing a little bee larva. Some of the cells may not be viable because the larva is infested with parasites or infected with chalkbrood disease. The limiting factor is that this bee does not pollinate tested NCRPIS crops species as well as honey bees and as a result is only been used experimentally.

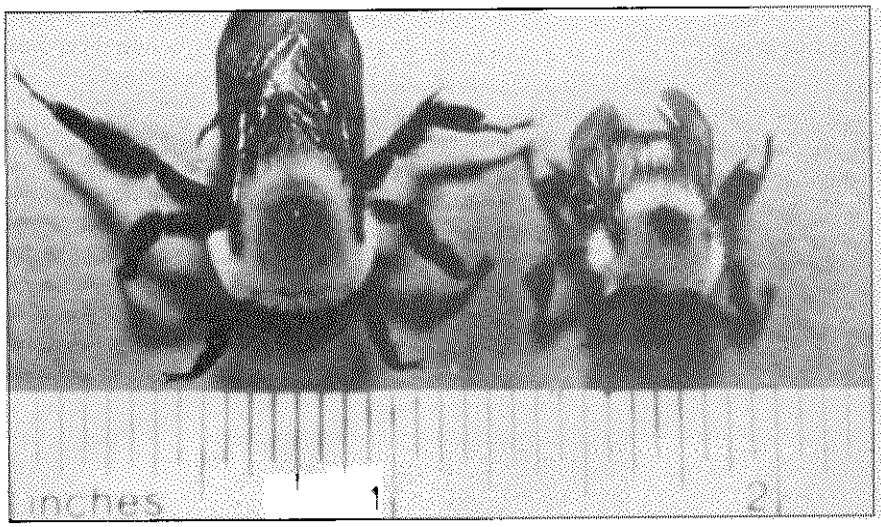
An attempt has been made to rear a native species of bumble bee (*Bombus bimaculatus*) at the station. In late April the only bumble bees out are mated queens which are captured for rearing purposes. Each queen is placed in a laboratory bumble bee domicile indoors with suitable nesting material and food (pollen cake and corn syrup). There are 30-50 worker bees by mid-July. The size of the workers vary with the quantity of food available during the larval stage. The adult bee emerges 16-25 days after the egg is laid. Developmental time varies because the brood nest temperature varies more widely than in a honey bee nest. Early in the season more environmental variability exists within the colony because there are fewer workers to help control the nest environment and to forage for food.

Drone bumble bees emerge around the first of July, queens in mid-July and then mating follows. Unfortunately, Craig has yet to get any of the queens mated indoors to survive the winter. Purchasing commercially available bumble bee colonies ready for pollination is cost prohibitive (i.e. about $275 per colony). However, he said that they will continue to experiment with these bees because they are such good pollinators.

The most successful alternate pollinator they have used at the PI Station is the hornfaced orchard bee (*Osmia cornifrons*). This bee was imported from Japan by the USDA and is now commercially available from only one source. (*Orchard Bees*, 1111 Cindy St., Auburn, IN 46706 Ph. 219-925-5076) This bee now is used to pollinate 75% of their canola cages. It pollinates the plants better than honey bees (i.e. more seed produced) and is less expensive to use. Craig's experience has been that the bees will not sting. The literature says if they do sting, it is about like a mosquito bite.

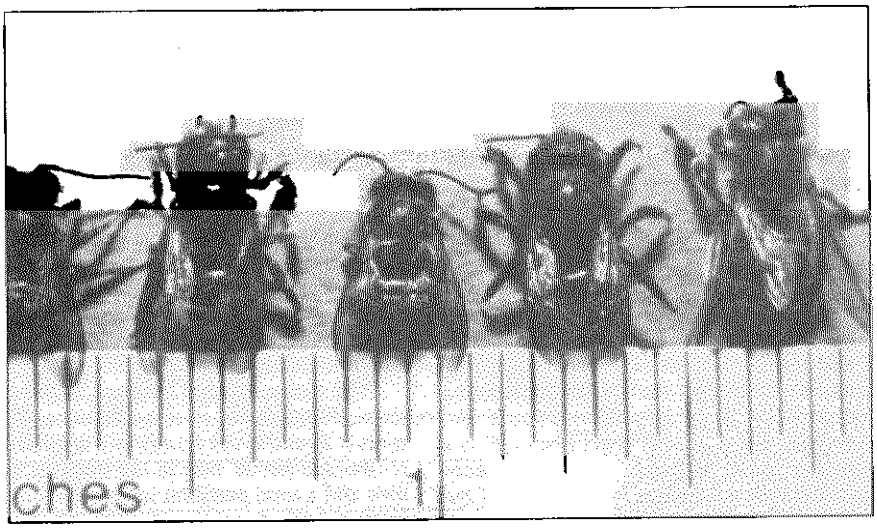
Hornfaced bees like other *Osmia* species (e.g. Orchard Mason Bees - *O. lignaria*) and leaf-cutter bees nest in holes in wood. This bee will also nest in cardboard tubes, like the ones used on some metal close hangers. When folded in half these tubes are just the right length for the bees. The bees are sold within cardboard tubes and should be kept in a moist cool place until blooming starts. The bees will start emerging in about three days at 70ºF.

The males emerge first and there is a ratio of five males to three females. The mated female then lays an egg on a pollen and nectar ball in the back of the tube and a mud partition is constructed to form a cell. A series of cells are constructed in this fashion, one on top of the other until about 10 cells fill the tube. The end of the tube is capped with an



Bumble bee (*Bombus bimaculatus*) queen (left) and worker (right)

Hornfaced bee (*Osmia cornifrons*) domicile for pollinating cucumbers in a field cage



Comparison of bees used for pollination. (From left to right) Hornfaced bees (male-left, female-right), Orchard mason bee (male-left, female-right), and Honey bee worker.

extra mud wall constructed after the last cell is completed.

The bees are only active collecting pollen and nectar for about six weeks in the springtime. The immature bees within the cells go through the same developmental stages as the honey bee inside the cells during the warm months and then overwinter as diapausing adults. An interesting aspect of this arrangement is how the series of bees hatch out as adults in the spring. The bee furthest from the outside opening was started first and is the oldest, yet for some unknown reason, this bee develops more slowly so that it is the last to be ready to emerge as an adult in the spring. I believe this is evidence of an intelligent creator designing these bees just perfectly for their environment.

Some disadvantages of hornfaced bees are:

- The winter in Iowa is too cold and dry for the bees to winter outside, so the tubes containing the bees must be brought indoors and kept just above freezing in a room with moist air. The bees will dry out and die unless the tubes are kept in a bag with a moist sponge in the refrigerator. Because of some of these difficulties, bees must be purchased each spring and are more expensive than alfalfa leafcutter bees (11 cents/bee vs 1 cent/bee) and only available from one supplier currently. About 1000 bees are required per acre, so the cost would be about $110 per acre.

- Hornfaced bees only work for spring blooming crops. Attempts to use with vine crops and sunflowers were not as successful because they will not tolerate the hot summer weather well and they are stressed by the longer cool storage period required.

However, the advantages outweigh the disadvantages when used for pollination of Canola in the field cages:

- Higher seed yields were obtained with the hornfaced bees than honey bees in the cages.
- There was less maintenance required (no feeding or other care for the bees during the off season) resulting in a lower cost per cage.
- Unskilled workers in the cages were more comfortable with the hornfaced bees because the bee does not sting.

In conclusion, Craig has been able to reduce the cost of pollinating the 1,000 field cages each year by rearing his own honey bees by overwintering indoors and raising his own queens, and by experimenting with alternate pollinators. Honey bees still make up the bulk of the pollination units, but the hornfaced bees are being effectively used in about 10% of their cages to increase seed yields and reduce the cost.