NCRPIS Controlled Pollination Project

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Historical development of controlled insect pollination at NCRPIS

Herb Spencer working in open plots in front of original wood frame screen cages containing plants and honey bees ca 1965.

- 1957 – Honey bees first used to pollinate cages of carrots, beets, celery, and onion [1]
  - cages were wood frames covered with screen; open plots of same accessions grown as well
- 1970's – 50 to 70 accessions of carrots, onions, parsley, and celery were cage increases of total 3000 to 3500 accessions grown annually
- 1978 – Major improvements in 5' x 5' x 20' ("small") field cage used for controlled insect pollination [2]:
  - Metal cage frame covered with Lumite^{R} flat screen
  - Nucleus honey bee hive box developed

Greg Jackson, Research Associate ca 1978 — Original sunflower cages ca 1982

- 1982 – First pollination of wild-type sunflowers in 10' x 10' x 20' ("large") cage constructed of metal frame and fitted Lumite^{R} screen [3]
- 1982 – First use of 50% sugar syrup to feed honey bee nucs retained inside of field cages instead of shifting bees to outside regularly [3]
- 1985 to1988 – Found that a combination of flies and honey bees used for carrot pollination resulted in a larger quantity of seed [4]
  - Houseflies were reared periodically at NCRPIS from 1985 through 1990; the protocols were improved and continuous rearing restarted in 2000
- 1989 to1990 – First use of alfalfa leafcutter bees and bumblebees in *Cuphea* field cage study [5]
- 1992 to 1995 – Studies of *Osmia* bee rearing and use for pollination of *Brassica* in early spring field cages [6-7-8]
- 1992 – Constructed indoor overwintering facility for honey bees [9]

Nucleus hives in overwintering room ca 1992 — *Daucus* (carrot) cages in greenhouse

- Winter 2000/2001 – First use of blue bottle flies:
  - Greenhouse carrot pollinations [10]
  - NCRPIS rearing trials [11-12]
- 2002 – Development of greenhouse cages for wild *Cucumis* pollination with weak honey bee nucs and alfalfa leafcutter bees
- 2003 – Honey bee feed container improvement to reduce robbing and syrup waste
- 2004 – Two 1000 gallon polyethylene storage tanks for corn syrup installed
- 2004 – First field trials of alfalfa leafcutter bees in primarily umbel-type field cages

Greenhouse cage for *Cucumis* pollination — Delivery of corn syrup to outer storage tank

Mission: Provide adequate numbers of healthy insects for plant pollinations

Controlled pollination of individual plant accessions maintained at NCRPIS helps retain the original genetic diversity of the plant populations.

Some plants are more effectively pollinated by insects than by hand. In addition, insects may be more economical (reduced time and labor costs) than hand pollination of crops.

At NCRPIS, insect pollinators are added to caged accessions of *Brassica* and other oilseed crops, miscellaneous umbels, wild-type sunflowers, vegetables such as cucurbits, as well as some ornamental and medicinal plant species.

Current insect pollinators used at NCRPIS

Honey bees (*Apis mellifera*) – the primary pollinator

- Placed in ca 800 cages per year, year round
- Used in both field and greenhouse cages
- Domiciles can be reused in other cages throughout the growing season
- Social bee with 2000 to 4000 bees per cage
- Traditionally used to pollinate many different plants and for honey production; at NCRPIS used on many plants but honey fed back to the bees
- Forage best at 15 to 32 C (60 to 90 F)
- Rearing is well established but costly due to the equipment and amount of continuing care required
- Can be aggressive and sting

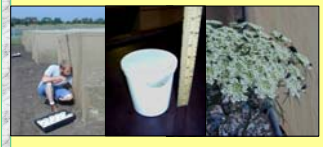
Bumblebees (*Bombus impatiens*) – the versatile pollinator

- Used in ca 10 cages per year, year round
- Used in both field and greenhouse cages
- Domiciles can be reused in other cages as long as colony thrives
- Social bee with ca 50 bees per domicile
- Traditionally used to pollinate many different plants; at NCRPIS used mainly for ornamentals with trumpet-shaped flowers
- Work in rainy, cool, windy weather at 13 to 32 C (55 to 95 F); active for many hours each day
- Rearing is difficult, so commercial colonies are used; expensive to purchase
- Can be mildly aggressive and sting

Osmia (*O. cornifrons* and *O. lignaria*) – the spring pollinator

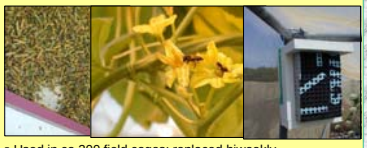
- Used in ca 200 field cages annually, April to June
- Can be used in 10 to 15.5 C (50 to 60 F) greenhouse in April
- Domiciles can not be relocated from one cage to another
- Solitary bee with ca 40 bee cells per cage
- Traditionally used for early blooming fruit trees; at NCRPIS used for early season *Brassica*, miscellaneous umbels and ornamentals
- Forage best at 10 to 30 C (50 to 85 F)
- Rearing is established, not costly, but can not be manipulated outside the normal springtime life cycle
- Non aggressive

Flies – the incidental pollinator (Houseflies or *Musca domestica* and Blue bottle flies or *Calliphora* sp.)



- Used in ca 20 springtime and 40 wintertime greenhouse cages
- Used in ca 80 summertime field cages
- Flies are replenished in cages weekly due to short life span
- Place ca 200 fly pupae per cage weekly after several days of incubation for good adult emergence
- Traditionally flies are not used as pollinators; at NCRPIS we have found addition of flies increases successful pollination of many umbels
- Work at 21 to 32 C (70 to 90 F), but not in rainy weather
- Rearing is well-established; pupae are low cost
- Non-aggressive but may be considered "irritating"

Alfalfa leafcutter bee (*Megachile rotundata*) – the supplemental pollinator



- Used in ca 200 field cages; replaced biweekly
- Used in ca 40 greenhouse cages; replaced weekly
- Variable life span depending on time of year and crop
- Solitary bee with 20 to 40 bees per cage; cells require 28 days incubation in lab
- Traditionally used to pollinate forage legumes and blueberries; at NCRPIS used on cucurbits, *Daucus, Brassica, Melilotus, Angelica, Potentilla, Ocimum*, wild-type *Helianthus*, all of which have small to medium size flowers of "flat or open" nature
- Work best at 26.5 C (80 F) or above in dry conditions, do not work well in cooler wetter weather
- Rearing is established, bees are low cost and require little care once they have emerged from leaf cells
- Non-aggressive but will bite if squeezed

Pollination personnel

Herb Spencer, Farm Superintendent, 1965-1985

Research Entomologist R.L. Wilson and technician Sharon McClurg ca 1991.

Kathy Schnable and Kathy Reitsma, vegetable curators assist H. Spencer with honey bee task, ca 1985.

Prior to 1986, curatorial and farm staff did all honey bee work in addition to their regular duties. In 1986 the first USDA-ARS technician (Bill Hotchkiss) was hired specifically to handle the controlled insect pollinators under the supervision of research entomologist R.L. Wilson (1980 – 2000). This pollinator position was later filled by Craig Abel (1988 – 1998) and upgraded to a support scientist. In addition to supplying honey bees for ca 800 field cages, Craig initiated a strong program of pollinator research with the aid of R. L Wilson. Since his hiring in 1999, Steve Hanlin has continued to supply high quality nucs of honey bees and has brought in alfalfa leafcutter bees with assistance from Sharon McClurg (1984 to present). A number of temporary student workers have also been essential to the success of the controlled pollination program.

Craig Abel (left) and Steve Hanlin (right) – entomologists in charge of NCRPIS controlled pollination program.

"Challenges" for pollination personnel

- Insects are always changing or exhibiting unexpected behavior
- Insects can not be pushed beyond normal biological limits or life cycle
- The caged environment required for controlled plant pollinations limits the pollinators that can be used successfully
- Difficult to provide a population of insects that appear to be adequately pollinating caged plant material
- Insects don't work well in cold temperatures or wet environments; they also don't work well in very high relative humidity found in greenhouses
- Non-entomology staff don't always consider ramifications of plant maintenance protocols on insect pollinators (e.g. watering, pesticide applications, etc.)

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