New developments in biological control of greenhouse vegetable pests

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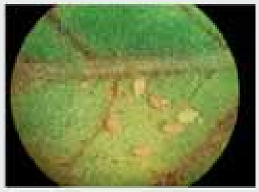
Agriculture and Agri-Food Canada   Agriculture et Agroalimentaire Canada

Talk Outline

- Quality of fresh vs stored biological control agents
- New predatory mite on the market
- Pest and biological control agent development under supplemental lighting
- Bee vectoring of microbial control agents

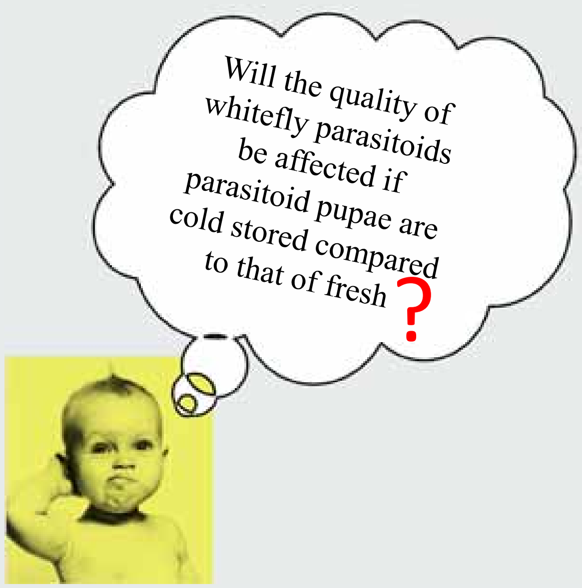
Effects of cold storage on the quality of whitefly parasitoids



Eretmocerus eremicus

Encarsia formosa

Fresh vs Cold stored parasitoids



Experiments (60% RH, 16:8 L:D)

Supplier Control: Tested immediately on receipt at $24^{O}C$.

Acclimatized: Stored at $12^{O}C$ for one week and cold stored at $7^{O}C$ for one more week.

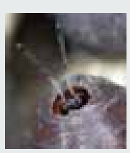
Cold stored 1 week: Cold stored at $7^{O}C$, for 1 week.

Cold stored 2 weeks: Cold stored at $7^{O}C$, for 2 weeks.

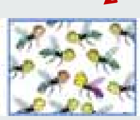
AAFC Control: Parasitoids were reared in the AAFC laboratory and used as fresh at $24^{O}C$.

Objectives

Quality

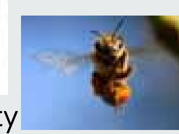


Emergence



Sex ratio

Longevity

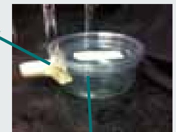


Flight capacity

Parasitism rate

Materials and methods
(Laboratory experiments)

Glass vial with parasitoid pupae



Emergence

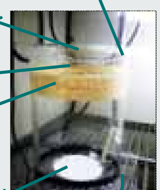
Emergence arena

Top plate

whitefly infested leaf

Sticky glue

masking tape



Flight

Petri dish with parasitoid pupae

Bottom plate

Materials and methods
(Laboratory experiments)

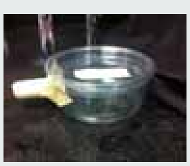
Parasitism

Muslin cloth cover

Leaf with whitefly scales

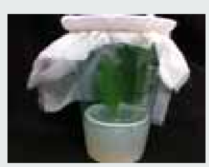
Food cup

Longevity



Without food

With food (10 % honey solution)



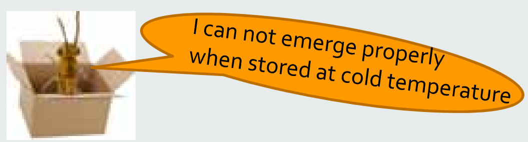
Leaves with whitefly scales

Leaves without whitefly scales

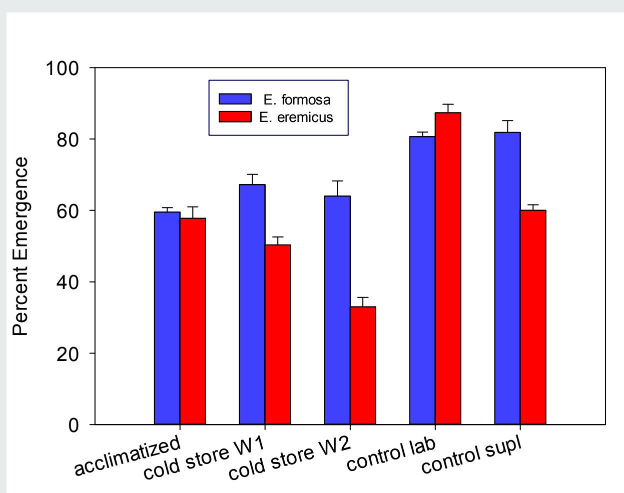
Data Collection

- Percentage emergence**?**
- Percentage of adults capable of flying**?**
- Sex ratio**?**
- Parasitism rate**?**
- Longevity**?**

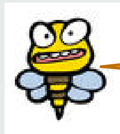
Results



The average percentage (±SE) of adult parasitoids emerged under the different treatments.

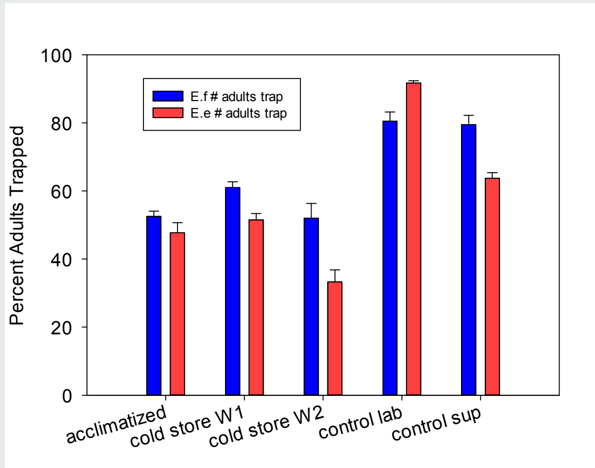


Results

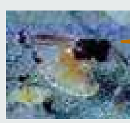


I can not fly properly
when stored at cold temperature

The average percentage (±SE) of adult trapped in flight chamber under different treatments.

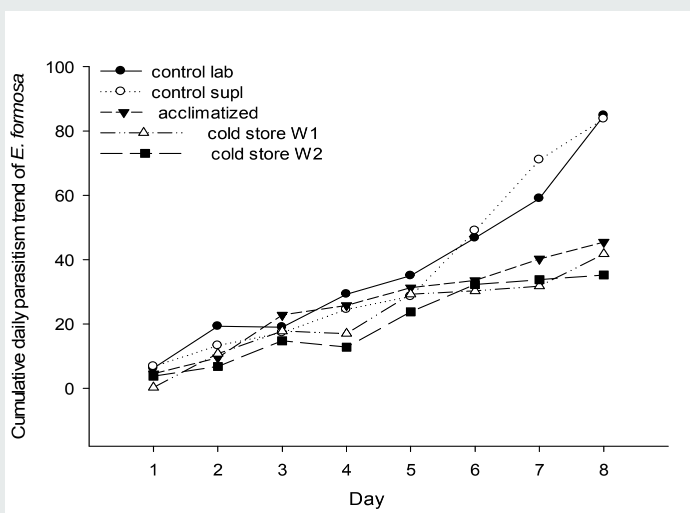


Results



I can not parasitize properly
when stored at cold temperature

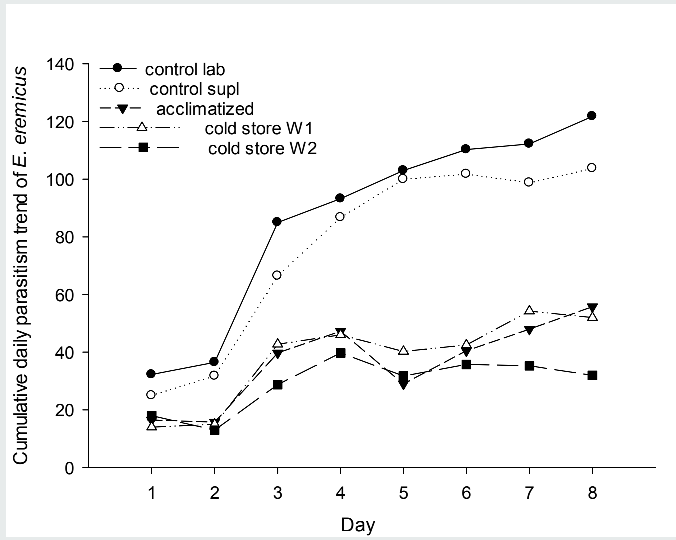
Mean numbers of scales parasitized by *E. formosa* over 8 days under different treatments.



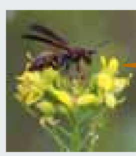
Results

I can not parasitize properly when stored at cold temperature

Mean numbers of scales parasitized by *E. eremicus* over 8 days under different treatments.

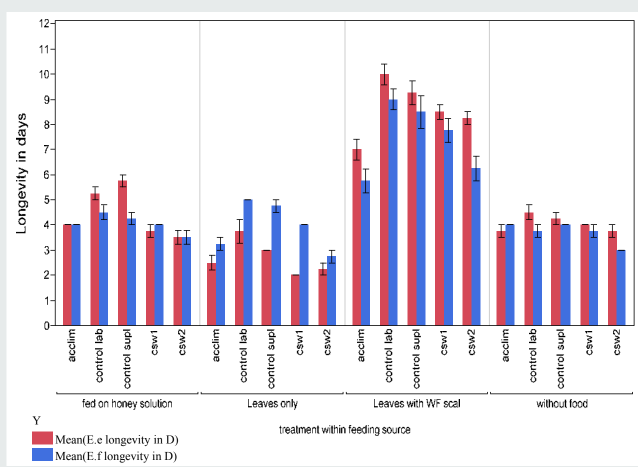


Results



I can live longer when have good food

The average (±SE) longevity (in days) of *E. formosa* and *E. eremicus* under different sets of food resources and storage regimes.



Conclusions

- ✓ More than 80% of the parasitoid adults should emerge from fresh pupae.
- ✓ Emergence and parasitism capacities of parasitoids decreased with increase in storage time.
- ✓ Storage has no effects on sex ratio.
- ✓ Reduction in parasitism rate is higher than decline in emergence rate following cold storage.
- ✓ *E. eremicus* lays maximum number of eggs during first five days of its life; *E. formosa* lays uniform number of eggs throughout its life.

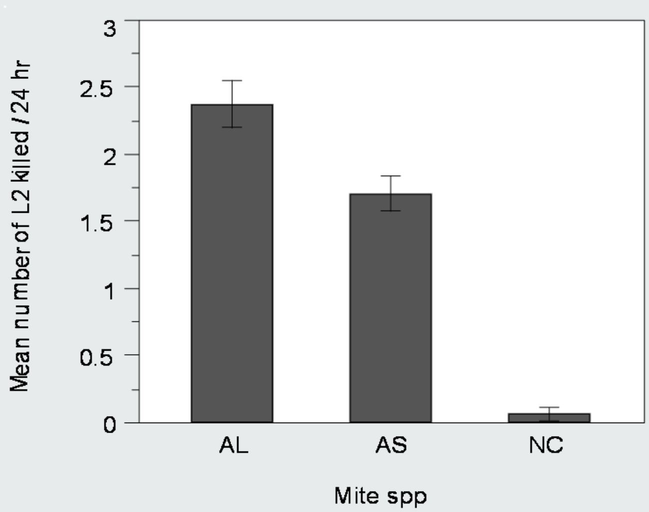
New predatory mite

Amblydromalus limonicus

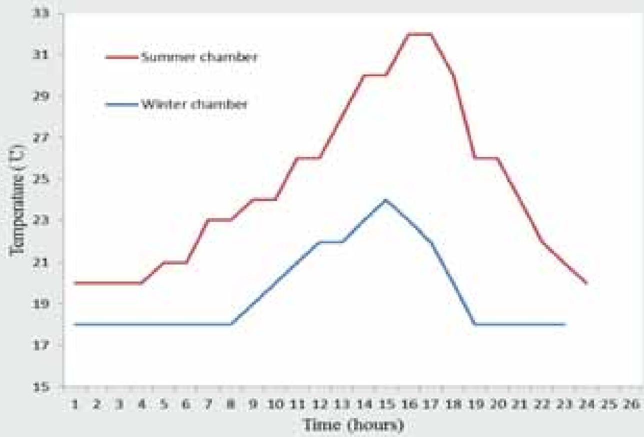
- Higher predation and egg laying rates than *Neoseiulus cucumeris* and *Amblyseius swirskii*
- Feeds on both larval instars of western flower thrips
- Active at lower temperatures (13 – 15°C)
- Feeds on immature stages of thrips, whiteflies and other mites

Life stages of western flower thrips

Predation rate of *A. limonicus*, *A. swirskii* and *N. cucumeris* on 2nd instar western flower thrips

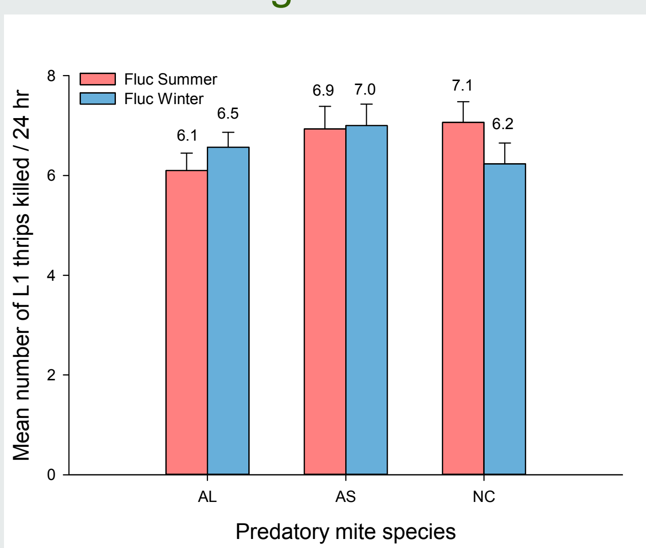


Predation and oviposition rates of *A. limonicus*, *A. swirskii* and *N. cucumeris* under fluctuating simulated summer and winter greenhouse conditions

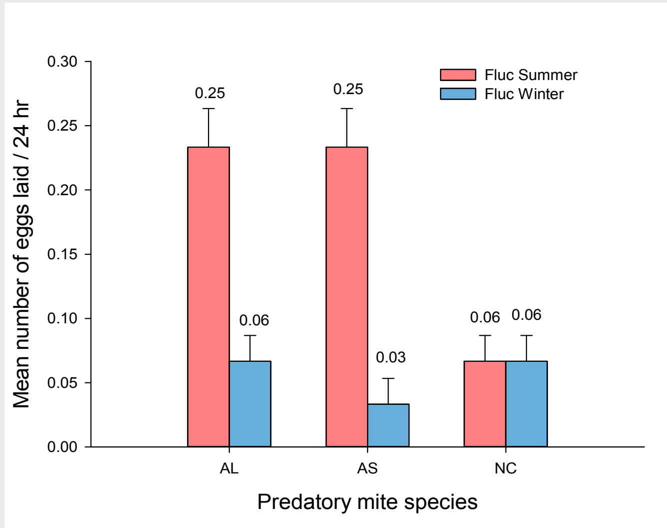


Summer: 24.5°C, 16L:8D and 83 W/m^2
Winter: 19.6°C, 8L:16D and 11W/m^2

Predation rates of *A. limonicus*, *A. swirskii* and *N. cucumeris* under fluctuating simulated summer and winter greenhouse conditions



Oviposition rates of *A. limonicus*, *A. swirskii* and *N. cucumeris* under fluctuating simulated summer and winter greenhouse conditions



Pest and biological control agent development under supplemental lighting

- Greenhouse whitefly development and egg laying

- Parasitism levels of *Encarsia formosa* and *Eretmocerus eremicus*

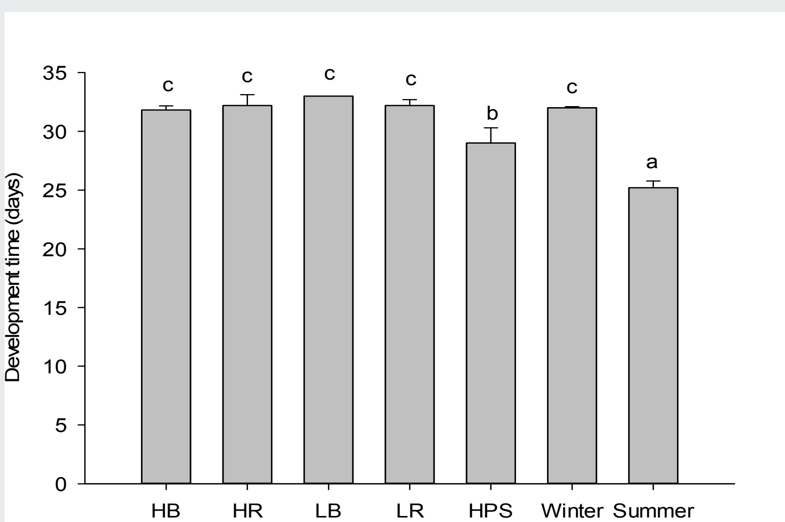
Controlled environmental chamber trials:
Greenhouse whitefly development

Treatments:

Summer = 24^{O}C, 16L:8D, 83W/m^2
Winter = 20^{O}C, 8L:16D, 11W/m^2
High pressure sodium lights (HPS) = 20^{O}C, 8L:16D,11W/m^2
High intensity blue LED (HB) = 20^{O}C, 20L:4D, 10.83W/m^2
Low intensity blue LED (LB) = 20^{O}C, 20L:4D, 2.7 W/m^2
High intensity red LED (HR) = 20^{O}C, 20L:4D,10.83 W/m^2
Low intensity red LED (LR) = 20^{O}C, 20L:4D, 2.7 W/m^2

4 replications
- 15 – 20 eggs per leaf

Controlled environmental chamber trials:
Greenhouse whitefly development



Controlled environmental chamber trials:
Greenhouse whitefly oviposition

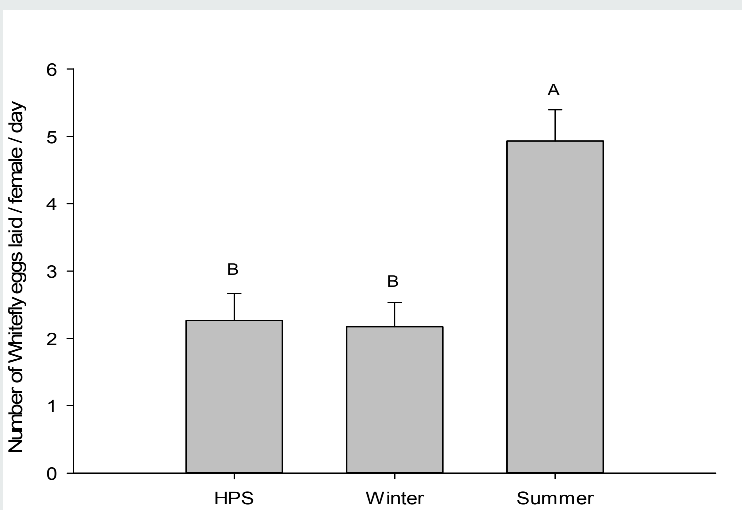
Treaments: Summer, Winter and HPS

A single pair of adult (male and female) whiteflies (< 48 h old) was released into the oviposition arena.

After 7 days, the leaves were removed and the number of eggs counted. A new leaf was placed in the arena and the processed repeated after another seven days.

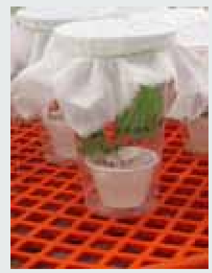
15 replications per treatment

Controlled environmental chamber trials:
Greenhouse whitefly oviposition

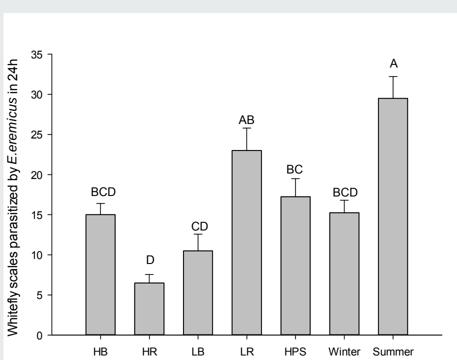


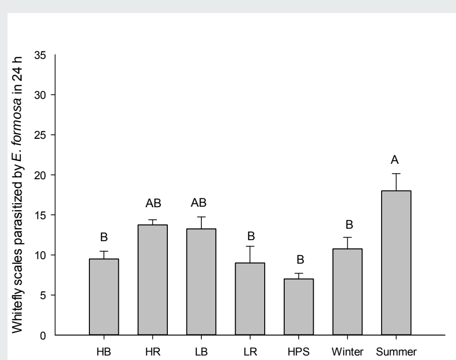
Controlled environmental chamber trials:
Parasitism rates for *Eretmocerus eremicus* and *Encarsia formosa*

- 7 light treatments
- Tomato leaves containing 100 – 200 whitefly eggs were placed in plastic arenas with 1 48-h old mated *E. eremicus* or *E. formosa.*
- Parasitoids were removed after 24 h and after 15 days, the number of parasitized whitefly pupae were recorded.
- 4 replications per treatment



Mean (± SE) number of whitefly scales parasitized by *E. eremicus* and *E. formosa* within 24 hours under different supplemental light treatments





BUMBLE BEES – A NEW DELIVERY SYSTEM FOR MICROBIAL CONTROL AGENTS FOR GREENHOUSE CROPS

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[1]Agriculture & Agri-Food Canada, [2]University of Guelph, [3]Al-balqa' Applied University, [4]National Academy of Agricultural Science and [5]Ontario Ministry of Agriculture, Food and Rural Affairs

Agriculture and Agri-Food Canada Agriculture et Agroalimentaire Canada

Canada

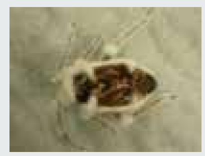
Why the pollinator-vector approach?

- Simultaneous combination of pollination and distribution of a biocontrol agent
- Continuous dissemination of the inoculum to the target plants
- Bees deliver the biocontrol agent (inoculum) to the right place
- Environmentally and economically friendly
- Potential compatibility with other bio-based IPM programs

Beauveria bassiana is an entomopathogenic fungus that attacks a wide host range of arthropods

In the greenhouse, it attacks:

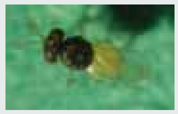
- greenhouse whitefly
- western flower thrips
- tarnished plant bug
- green peach aphid



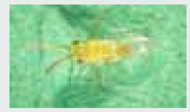
Background of bee vectoring technology on greenhouse crops

- In 2003, showed that bee pollinators can also be used to deliver the entomopathogen, *B. bassiana*, for insect pest control (*Lygus* and thrips) on greenhouse pepper.
- By 2005, determined the optimal concentration of bee vectored *Beauveria* for pepper and tomato for whiteflies, thrips, aphids and *Lygus*.
- By 2006, proved that bumble bees can vector *B. bassiana* and *Clonostachys rosea* simultaneously as a single inoculum for insect pest control and plant disease suppression.
- 2006 and 2008, conducted commercial greenhouse trials to determine the effect of inoculum dispensers on bee foraging activity (pollination and fruit yield) and to determine where the inoculum was deposited on the crop (ie., flowers and leaves).
- 2008-09, determined that bee vectored *B. bassiana* had minimal impact on greenhouse biocontrol agents (predatory mites and parasitoids).
- 2010-11, demonstrated that bumble bees can vector AcMNPV baculovirus and *Bacillus thuringiensis* subsp. *kurstaki* (Bt)for cabbage looper control.
- 2011-13, demonstrated that bumble bees can vector *C. rosea*, *B. bassiana* and Bt in outdoor crops (strawberries, blueberries, sunflowers) for disease and pest management.

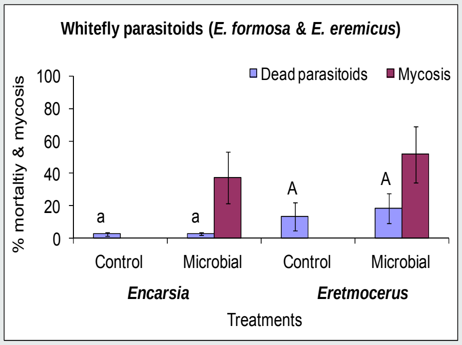
Impact of bee vectored *Beauveria* on greenhouse biocontrol agents

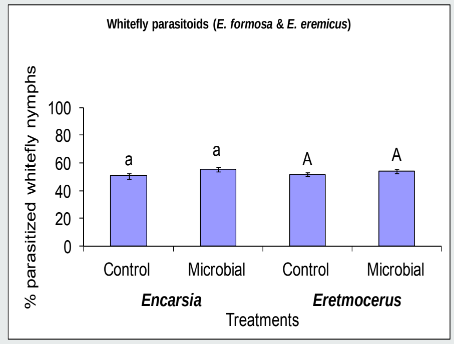


Encarsia formosa

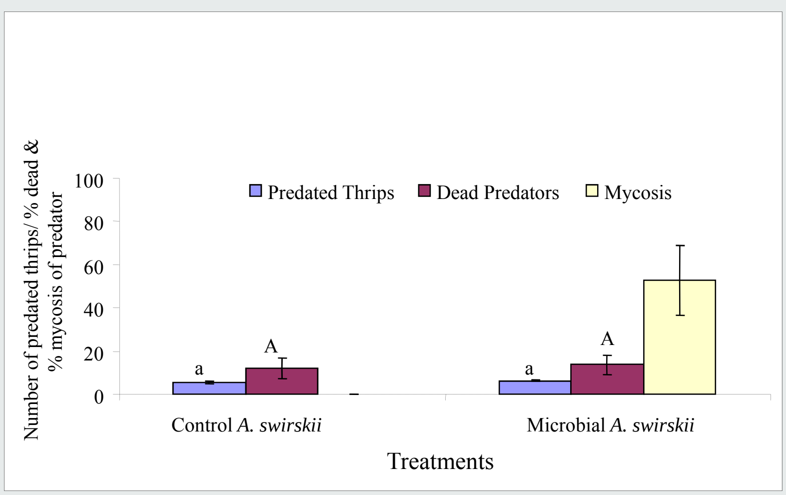


Eretmocerus eremicus





Impact of bee vectored *Beauveria* on the predatory mite, *Amblyseius swirskii*



Impact of bee vectored *Beauveria* on the predatory bug, *Orius insidiosus*

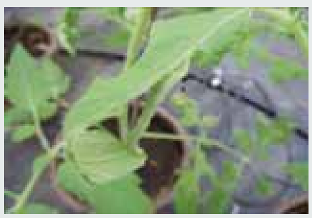
Control mortality = 16.9% | *Beauveria* mortality = 41.2%

Control predation rate = 19.5 | *Beauveria* predation rate = 21.1

Summary

- Bee-vectored *B. bassiana* at a concentration of 1.37 x 10^{10} conidia of *Beauveria* per gram of inoculum did not have a negative impact on *E. formosa, E. eremicus, A. colemani* or *A. swirskii* as indicated by percentage mortality and mycosis compared to non-*Beauveria* control treatment.
- Parasitism or predation levels were also not negatively impacted.
- Bee mortality was not significantly different between the microbial and control treatments.

Bee vectoring of AcMNPV baculovirus and *Bacillus thuringiensis* subsp. *kurstaki* for cabbage looper control



Mean mortality (± SE) of *Trichoplusia ni* exposed to bee vectored and spray application of AcMNPV

Treatment	N	4 days post treatment		7 days post treatment	
		Mortality (%)	Corrected Mortality (%)	Mortality (%)	Corrected Mortality (%)
Sprayed AcMNPV (full rate)	3	98.3 ± 1.67A	98.3 ± 1.73A	100.0 ± 0.00A	100.0 ± 0.00A
Sprayed AcMNPV (½ rate)	3	98.3 ± 1.67A	98.3 ± 1.73A	100.0 ± 0.00A	100.0 ± 0.00A
Bee vectored AcMNPV(full rate)	3	55.0 ± 13.23B	53.5 ± 13.67B	96.7 ± 1.67A	96.5 ± 1.73A
Bee vectored AcMNPV (½ rate)	3	40.0 ± 12.58B	37.9 ± 13.00B	81.7 ± 8.82A	81.0 ± 9.12A
Bee vectored AcMNPV (inactivated)	3	25.0 ± 5.00BC	22.4 ± 5.20B	38.3 ± 16.41AB	36.2 ± 16.98B
Control (bees and no AcMNPV)	3	3.3 ± 1.67C	-	28.3 ± 6.01B	-

N = numbers of samples collected (a total of 20 individuals were collected per sample). Within a column, means followed by different letters are significantly different at $P<0.05$ using Tukey HSD test.

Mortality (± SE) of *Trichoplusia ni* to bee vectored and spray application of *Bacillus thuringiensis* subsp. *kurstaki*

Treatment	N	4 days post treatment		7 days post treatment	
		Mortality (%)	Corrected Mortality (%)	Mortality (%)	Corrected Mortality (%)
Dipel 2X DF	3	100.0 ± 0.00	100.0 ± 0.00a	100.0 ± 0.00	100.0 ± 0.00a
Dipel (undiluted)	3	100.0 ± 0.00	100.0 ± 0.00a	100.0 ± 0.00	100.0 ± 0.00a
Dipel (½ conc.)	3	100.0 ± 0.00	96.6 ± 1.70a	100.0 ± 0.00	100.0 ± 0.00a
Dipel (¼ conc.)	3	93.0 ± 6.70	89.8 ± 7.76a	100.0 ± 0.00	100.0 ± 0.00a
Dipel (⅛ conc.)	3	87.0 ± 8.80	84.7 ± 7.76a	88.0 ± 6.00	88.1 ± 6.11a
Dipel (inactivated)	3	13.0 ± 8.80	10.7 ± 9.09b	2.0 ± 1.70	1.1 ± 1.13b
Control (bees and no Dipel)	3	2.0 ± 1.70	-	2.0 ± 1.70	-

N = numbers of samples collected (a total of 20 individuals were collected per sample). Within a column, means followed by different letters are significantly different at *P*<0.05 using Tukey HSD test.

Sutton – University of Guelph

New bee vectoring dispenser

Bee Vectoring Technology Inc.

Biobest Belgium NV

FLYING DOCTORS®

Carrier issues

Caking and crusting over of the inoculum surface due to fecal and fluid deposition by the bees and high humidity

A new carrier was developed and patented which included corn flour, desiccant, sticker, etc.

Pest Management Regulatory Agency (PMRA) recently announced the approval of a novel pollinator biocontrol vector application method for the delivery of Botanigard ® 22WP to the target in pollinated greenhouse crops.

BOTANIGARD 22WP
Wettable Powder Mycoinsecticide
For use in controlling whitefly, aphids, and thrips in Greenhouse Ornamentals and Vegetables
COMMERCIAL
WARNING – EYE IRRITANT
CAUTION – SKIN IRRITANT
POTENTIAL SENSITIZER
READ THE LABEL BEFORE USING
GUARANTEE: *Beauveria bassiana* strain GHA.........4.4X1013 conidia / kg
KEEP OUT OF REACH OF CHILDREN
CAUTION
REGISTRATION NO. 29321 PEST CONTROL PRODUCTS ACT
Warning: This product contains the allergen sulfite.
NET CONTENTS: 500 grams
Laverlam International Corporation (LVM)
P.O. Box 4109,
Butte, MT 59702
USA
Phone: BioWorks (North American Distributor)
1-800-877-9443
2011-2974
2012-11-16

POLLINATOR BIOCONTROL VECTOR APPLICATION METHOD
For suppression of whiteflies, aphids and thrips in bumble bee pollinated greenhouse crops
Introduction
This application method uses a microbial inoculum dispenser that is attached to the front of a bumble bee hive. As bumble bees exit the hive through the dispenser, BotaniGard 22WP accumulates on their legs and body hairs. The bumble bees then transport and deposit the product on plant foliage, flowers and fruit during foraging and grooming. This continuous delivery of the bioinsecticide to the target sites on the plants enables management of whiteflies, aphids and thrips in bumble bee pollinated greenhouse crops.
The pollinator biocontrol vector application method facilitates the deposition of BotaniGard 22WP directly on the plant where the pests are found, reduces loss to ground deposition, continuously exposes the pest to the product, and limits aerosol concentration. Furthermore, this application method provides value added benefit to normal crop pollination, combining pollination with simultaneous pest control.
This application method can be used to deliver Botanigard 22WP with bumble bees for the management of pests.

Future directions

- Conduct commercial greenhouse trials to determine the number of dispensers per hectare
- Investigate the possibility of combining three microbial agents into a single inoculum
- Investigate the idea of using other insects as vectors of microbial agents

Acknowledgements

UNIVERSITY of GUELPH

biobest BIOLOGICAL SYSTEMS

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Dana Gagnier
Gillian Ferguson
and numerous coop and summer students

Bee Vectoring Technology Inc.

Adjuvants plus

réseau biocontrôle biocontrol network

LAVERLAM INTERNATIONAL

RDA 농촌진흥청

Growing Forward | Cultivons l'avenir

Agriculture and Agri-Food Canada | Agriculture et Agroalimentaire Canada

AAC

Improved Farming Systems and Practices Initiative