Diversity by Design: Using Trap Crops to Control the Crucifer Flea Beetle

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SCIENCE & TECHNOLOGY POLICY FELLOWSHIPS



Crucifer Flea Beetle (CFB)

- Phyllotreta cruciferae
 - Feeds on plants in the family Brassicaceae
 - Arugula
 - Broccoli
 - Pac Choi
 - Cabbage
 - Collards
 - Kale



Crucifer Flea Beetle (CFB)



Broccoli Leaf (Brassica oleracea var. italica)



Pac Choi (Brassica rapa var. pekinesis)

CFB Lifecycle



Figure 2. Flea beetle life cycle. (Photos by Ken Gray, courtesy of Oregon State University)

CFB Damage

- Feeding damage
 - Slows growth
 - Scars foliage
 - Decreases yields
 - Kills small plants/transplants





Broccoli Leaf (Brassica oleracea var. italica)

Pacific Gold Mustard (Brassica juncea)

Control Options

- CFB move into fields from surrounding habitats
 - Floating row covers
 - Organic approved chemical controls
 - Trap cropping



Severe CFB Damage on Broccoli

Trap Crops

- Trap crops lure pest insects away from target (cash) crops
- Recommended that the trap crop be <a>10% of the crop area used
- Once CFB start to feed on the trap crop, they can be controlled using different methods
 - Botanically-based insecticide
 - Tilling the infested trap crop into the ground



Mustard Trap Crop Flanked by Broccoli (Target Crop)

Trap Crops







A perimeter trap crop is planted around a field border



A strip trap crop is planted along one side of a field

Habitat Diversity

- Greater diversity of prey and host species
- More stable populations of predators and parasitoids
- Pest problems more severe in simple habitats
 - Pimentel (1961)
 - Janzen (1970)
 - Root (1973)
 - Risch et al. (1983)



Greentree Naturals, Sandpoint, ID



Pimentel 1961, Annals of the Entomol. Soc. Am: "Considerable evidence in the literature suggests that the lack of species diversity [in] communities modified by cultivation...may be responsible for the outbreaks which are so typical of these simplified communities"



Altieri 1999:

"The key is to <u>identify the type of biodiversity that is desirable</u> to maintain and/or enhance...ecological services, and to determine the best practices to encourage the desired biodiversity components."

> This requires quite a detailed understanding of biodiversity effects

Different species "complement" one another?



Ecological Benefits

- Biodiversity can enhance ecosystem function
- Reverse effects of species loss by restoring
 - Interspecific complementarity
 - Ecological benefits of biodiversity
- Agricultural systems
 - Organic farming
 - Trap crops



Diverse Trap Crop

Main Questions

- 1. Could we modify farming practices to capture these biodiversity benefits?
- 2. Does species biodiversity within trap crops improve pest control?
- 3. Is there an optimal trap crop distance?

OBJECTIVE

Investigate the use of simple and diverse trap crops as a tool for managing CFB populations



Diversity Experiment 2009

- Plot Locations
 - Moscow, Idaho (East)
 - Mt. Vernon, WA (West)
- Simple trap crop treatments
 - 5 monocultures
- Diverse trap crop treatments
 - 5 unique treatment combinations of 4 species (polycultures)



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Vollow Pocket	Rarbaraa vulaaris
fellow Rocket	Burbureu vulguris
Pacific Gold Mustard	Brassica juncea
Dwarf Essex Rape	Brassica napus
Green Glaze Collard	Brassica oleracea var. acephala
Pac Choi	Brassica rapa var. pekinensis

Different trap crop species "complement" one another?

- Mixture of chemical profiles
 - Different primary glucosinolates and concentrations
- Different physical structures
 - Glossy leaves versus hairy leaves
- Different phenologies



Simple Trap Crop Treatments

Yellow Rocket	Mustard	Rape	Pac Choi	Collard
Yellow Rocket	Mustard	Rape	Pac Choi	Collard
Yellow Rocket	Mustard	Rape	Pac Choi	Collard
Yellow Rocket	Mustard	Rape	Pac Choi	Collard
Yellow Rocket	Mustard	Rape	Pac Choi	Collard

Diverse Trap Crop Treatments

- Yellow Rocket	- Mustard	- Rape	- Pac Choi	- Collard
x	Yellow Rocket	Yellow Rocket	Yellow Rocket	Yellow Rocket
Mustard	x	Mustard	Mustard	Mustard
Rape	Rape	x	Rape	Rape
Pac Choi	Pac Choi	Pac Choi	x	Pac Choi
Collard	Collard	Collard	Collard	x

Trap Crop Physical Layout



Trap Crop Physical Layout



Methods



Recorded visual observations of CFB on broccoli

suction sampler

Results Diversity Experiment 2009

- The importance of diverse trap crops varies with time and site (P = 0.032)
 - East: diverse trap crops more effective early season
 - West: diverse trap crops more effective mid season

- Certain monocultures more effective than others
 - Pacific gold mustard
 - Pac Choi
 - Rape

***** *P* < 0.05

Field Experiment: Experimental Design 2010

- Plot Locations
 - Moscow, Idaho (East)
 - Mt. Vernon, WA (West)
- Simple trap crop treatments
 - 3 monocultures
- Diverse trap crop treatments



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- Low diversity: 3 unique treatment combinations of 2 species (polyculture)
- High diversity: 1 treatment combinations of 3 species (polycultures)

Pacific Gold Mustard	Brassica juncea	
Pac Choi	Brassica rapa var. pekinesis	
Rape	Brassica napus	

Simple Trap Crop Treatments

Mustard	Pac choi	Rape
Mustard	Pac Choi	Rape
Mustard	Pac Choi	Rape
Mustard	Pac Choi	Rape

Low Diversity Trap Crop Treatments

- Mustard	- Pac choi	- Rape
X	Mustard	Mustard
Pac Choi	X	Pac Choi
Rape	Rape	X

High Diversity Trap Crop Treatment

N	lustard
Ра	ac Choi
	Rape

Trap Crop Physical Layout



Methods



Recorded visual observations of CFB on broccoli

suction sampler





Observational Data



Broccoli

Pac Choi Rape Mustard



Broccoli Whole Plant Dry Weight



Biodiversity Effects

- Diverse communities
 - Can out-perform those that are species-poor
 - Complementarity
 - Species identity effects
- Overyielding
 - Impact of diverse communities exceeds that of single species
- Dmax
 - Dmax = $(O_j E_j)/E_j$
 - Compelling evidence that species are complementing one another
 - Represents true emergent effects of increasing species richness (Loreau et al. 2006)

Dmax Broccoli Whole Plant Dry Weight



CFB in Trap Crops and Broccoli

Diversity: *P* = 0.264

Diversity: *P* = < 0.001



Summary

0 = 1 = 2 < 3

• The "right type" of diversity

Conclusions

- Species complementarity
 - Balancing resource use
- Diverse trap crop
 - Chemical profiles
 - Physical structures
 - Plant phenologies
- Specific mechanisms unknown
- Pest behavior is important



West location: Mt. Vernon, WA

OBJECTIVE

 Trap crop proximity:
Does trap cropping alter CFB distribution in the crop?

2) CFB removal:

Does spraying the trap crop improve CFB control?



Experimental Design 2011

- Plot locations
 - Moscow, Idaho (East)
 - Mt. Vernon, WA (West)
- Diverse trap crop
- Broccoli distances
 - 0.5 m (near)
 - 4 m (middle)
 - 11 m (far)
- Treatment
 - Sprayed
 - Not Sprayed
 - Control (no trap crop)



Trap Crop Species

Pacific Gold Mustard	Brassica juncea
Pac Choi	Brassica rapa var. pekinesis
Rape	Brassica napus

Physical Layout



Physical Layout



Methods



Sampled CFB populations in trap crops using D-Vac suction sampler



Recorded visual observations of CFB on broccoli Recorded broccoli whole plant dry weight

Results



CFB in Trap Crops

Treatment $P = < 0.0001^*$



Trap crop species number

Broccoli Whole Plant Dry Weight

Treatment P = < 0.0001*



Trap crop species number

Broccoli Whole Plant Dry Weight

Treatment P = < 0.0001*



CFB on Broccoli

Treatment $P = < 0.0001^*$ Distance $P = < 0.0001^*$ Distance x Time $P = < 0.0001^*$ Distance x Site x Time $P = < 0.0001^*$





CFB on Broccoli

Treatment $P = < 0.0001^*$ Distance $P = < 0.0001^*$ Distance x Time $P = < 0.0001^*$ Distance x Site x Time $P = < 0.0001^*$

- 1) CFB concentrate at the edge of crop at low populations
- 2) CFB may not feed heavily on plants where they are found on
- 3) Spraying trap crop did not improve broccoli whole plant dry weight



Conclusion

• Diverse trap crop was highly effective

 CFB appeared to readily move between the trap and broccoli crops

 Apparently, CFB concentrated feeding on the trap crop when given this choice



Grand Conclusion

- Trap crop biodiversity improves CFB control
- Importance of pest behavior
- Landscape diversity decreases pest numbers
- Manipulating diversity on a finer scale

Thank you!

- Questions?
- Register for upcoming webinars and view recorded eOrganic webinars at <u>http://www.extension.org/pages/25242/webinars-by-</u> <u>eorganic#.VFegOBZuVMs</u>
- Additional organic farming questions? Ask them at <u>https://ask.extension.org/groups/1668/ask</u>







Dry Weight vs. Fresh Weight

