The Journal of Extension

Volume 42 | Number 6 Article 5

12-1-2004

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Recommended Citation

(2004). Moving Towards Ecologically Based Pest Management: A Case Study Using Perimeter Trap Cropping. *The Journal of Extension, 42*(6), Article 5. https://tigerprints.clemson.edu/joe/vol42/iss6/5

December 2004 // Volume 42 // Number 6 // Feature Articles // 6FEA2

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Moving Towards Ecologically Based Pest Management: A Case Study Using Perimeter Trap Cropping

Abstract
Despite almost a half-century of IPM research and Extension efforts, pesticide usage continues to rise. Scientists and policy-makers have criticized IPM for a continued dependency on chemical solutions. They argue that long-term solutions will only be found by restructuring the crop system to incorporate preventative ecological measures that keep organisms from reaching pest status. Extension and IPM risk losing credibility on environmental issues concerning pesticides and risk losing funding to organizations that are willing to develop ecologically based pest management solutions. Perimeter trap cropping is presented as one example of an ecologically based solution.

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Introduction

In recent years, Integrated Pest Management (IPM) Programs have been criticized for relying too much on chemical solutions and for having a low adoption rate of low-risk, biologically based tactics (Anonymous, 2001; Ehler & Bottrell, 2000; Lewis, van Lenteren, Phatak, & Tumlinson, 1997). Some have argued that the original meaning of the term "integrated" in IPM has been lost. It is claimed that the term originally referred to "compatible" management techniques that minimized disruption of natural enemies (Ehler & Bottrell, 2000).

Lewis et al. (1997) argue that we must move away from quests for short-term, therapeutic interventions ("silver bullets"), such as pesticides, that merely treat the symptoms of an unbalanced ecosystem. They advocate that researchers concentrate on developing long-lasting solutions that build in an array of preventative, natural regulators.

This means that merely switching from chemicals to selective microbial pesticides, biocontrol agents, or biotech products does not address the underlying weaknesses of conventional pest management systems. The basic tenet described by Lewis et al. (1997) and others is that nature will always counter therapeutic approaches and render them ineffective in the long term. Therapeutic tactics should serve as a backup to built-in preventative measures while balance is restored to the system, not as the primary means of pest control.

To implement an ecologically based approach to pest management, we need to modify crop production designs, using principles capable of containing population levels of a variety of pests and pest complexes on multiple commodities. In ecological terms, this involves moderating or dampening pest populations' boom and bust cycles so that populations of individual pests remain at low carrying capacities and, ideally, below economic thresholds. To accomplish these goals, Lewis et al. (1997) suggest that new designs concentrate on managing the farm environment through ecosystem enhancements (i.e., landscape ecology), crop attributes, or other means that help stabilize the population of species throughout the food web.

To scientists and Extension educators involved exclusively in conventional agriculture or pesticide-oriented IPM programs, Lewis' suggestions might seem little more than a pipe dream. It is often hard to imagine how a redesigned system might successfully incorporate good ecological principles, eliminate pesticides from crops, and meet all the short-term demands of modern agriculture and the marketplace. Perimeter trap cropping represents one possible redesign of the crop production and pest management system that incorporates natural population regulators, plant attributes, and a conservative trap crop spatial orientation to improve pest control.

Definition and Function of Perimeter Trap Cropping (PTC)

Webster's Dictionary (Guralnik, 1980) defines "perimeter" as "the outer boundary of a figure or area" and as "a boundary strip where defenses are set up." Perimeter trap cropping involves planting a more attractive host plant to completely encircle and protect the main cash crop like fortress walls. Other perimeter defenses such as border sprays or biological, mechanical, and/or cultural controls can be added to help increase efficacy.

Perimeter trap cropping functions by intercepting pest migration, regardless of the direction of attack. It then concentrates pest population(s) in the border area, where they can be retained or controlled. Natural enemies are conserved by eliminating insecticide use on the main cash crop. Crop losses can be further reduced if the target pest(s) are also disease vectors (Boucher & Durgy, 2004).

Perimeter trap cropping has provided excellent pest control and dramatically reduced pesticide use and costs on a variety of crops. Researchers in Florida were able to keep diamondback moth infestations from reaching action thresholds in commercial cabbage fields by surrounding them with two rows of collards (Mitchell, Hu, & Johanowicz, 2000). A naturally occurring parasitic wasp helped control the moth population on the collards and reduced the number of individuals that spread into the cabbage. Cabbage fields protected by the PTC system in the study used 56% fewer insecticide sprays than conventional fields and saved $47 to $63 per acre in chemical costs.

Brewer and Schmidt (1995) used early-maturing sunflowers to surround and protect oilseed sunflowers from the red sunflower seed weevil. Yield and damage levels were similar in PTC sunflower fields and those treated with full-field sprays, but the trap crop system was more economical. Aluja et al. (1997) almost eliminated papaya fruit fly damage in an unsprayed papaya planting in Mexico by using a PTC system.

Boucher and Durgy (2003) used a sprayed trap crop of 'Blue Hubbard' squash around summer squash to reduce cucumber beetle populations by up to 93% compared with check plots. Commercial growers using PTC for squash stated that the system improved and simplified pest control, reduced pesticide use (93%) and crop loss (18%), and saved time and money compared to their conventional programs (Boucher & Durgy, 2004). Boucher, Ashley, Durgy, Sciabarrasi, and Calderwood (2003) used hot cherry peppers to protect bell pepper plots from attack by the pepper maggot. In research plots, pepper maggot damage was reduced by over 90% using PTC. Economic analysis of PTC use in a commercial pepper field showed that net profits were increased by $153 per acre.

Field Demonstrations

In 2003, four Connecticut growers surrounded 18.25 acres of peppers with a hot cherry pepper trap crop. The PTC plantings ranged from 1 to 12 acres in size. These growers have all used PTC to protect their bell peppers from pepper maggot for 2 to 4 years. One additional grower tried to protect eggplant from pepper maggots with hot cherry peppers for the first time in 2003. He converted to PTC after having 100% of the eggplant crop damaged by maggots in the past few years, despite multiple full-field sprays. There are currently no effective insecticides registered to control pepper maggots on eggplant.

Growers used 1 to 4 rows of trap crop along the length of their plantings. Two to six cherry pepper plants were used at both ends of each pepper or eggplant row to complete the perimeter barrier. The trap crop was transplanted at the same in- and between-row spacing as the main crop. Two growers used bare-ground culture to produce their peppers or eggplants, while the others used a plastic-mulched system of production, with either trickle or overhead irrigation.

Prior to their first season using pepper maggot PTC, Extension personnel met with growers and provided fact sheets and advice to help them implement and maintain the system on their farms. Certain important concepts were emphasized with growers prior to the beginning of the program:

1. Plant the trap crop on good ground, so that it remains healthy and completely encircles the main crop, without large gaps in the perimeter;

2. Apply a foliar insecticide application to the perimeter within a week of finding pepper maggot fruit stings (oviposition scars) on the trap crop or within a week of capturing adult flies on

baited traps (Boucher & Ashley, 2001); and

3. Monitor the field continuously until mid-August and be prepared to make 1-3 additional perimeter applications, if necessary.

Repeat perimeter applications were considered justified if additional pepper maggot flies were found while checking traps at weekly intervals, or if stings continued to accumulate on the trap crop fruit (Boucher & Ashley, 2001). Full-field sprays for pepper maggot have never been needed on any of the farms while using PTC with sprayed perimeters. Extension personnel helped three growers monitor pest populations and time perimeter pesticide applications in 2003. The other growers did their own monitoring or scouting after the year of their initial training, or relied on a consultant to provide information about insecticide timing.

Growers used backpacks, boom sprayers, or mist blowers to apply dimethoate or acephate to the trap crop row(s). Three growers who used boom sprayers or mist blowers applied sprays to the outer 12 to 25 feet of the block (trap and main crop) by circling the field once.

At the end of the 2003 growing season, participants were surveyed and asked to compare the results of using the pepper maggot PTC system to prior years using a conventional program that relied on full-field insecticide sprays. Growers were asked to comment on PTC and to rate a list of possible benefits on a scale of zero (no benefit) to three (high benefit). They were also asked to rate the PTC program for simplicity/complexity, describe their overall satisfaction level with the system, and rate the training program overall.

Results of PTC User Surveys

All (100%) of the growers stated that their pest control was much better using PTC than in previous years without a trap crop system. Mean damage estimates due to pepper maggots were 12% using multiple full-field sprays and < 1% using PTC.

All respondents reported pesticide savings using the trap crop system. Growers applied an average of 1.4 insecticide sprays targeting pepper maggots to the trap crop, compared with 2.2 full-field sprays using their conventional programs. The use of insecticide active ingredient for pepper maggot control was reduced by 0.7 pounds per acre (90%) using PTC. All growers had a history of applying additional sprays for aphids or other secondary pests prior to using PTC. None of the growers required sprays for secondary pests in 2003.

Growers estimated that the total cost of installing and maintaining the PTC system ranged between $30 and $93 per acre, yet all said that they saved money using the trap crop system. They estimated their overall savings from using PTC at between $1 to $1,000 per acre and attributed most of the savings to improved pest control, crop quality, and yields.

Eighty percent of the growers rated the PTC system as simpler (20%) or much simpler to use (60%) than their traditional pest control program on peppers, while one grower said that using a trap crop was a little more complex. Sixty percent of the growers stated that they saved time using the PTC system compared to using their conventional program. One producer said that PTC took approximately the same amount of time as multiple full-field sprays, and one grower said that it took more time.

All of the growers gave the PTC system high marks when rating a list of possible PTC benefits (Table 1). A majority of respondents rated 10 of the categories a 3, the highest possible rating. They also mentioned the following additional benefits of using PTC: the security of "knowing that you're controlling the pest" with PTC and doing "less mechanical damage by not going in [to the field] with a sprayer when the [eggplant] crop is big and has lodged."

Table 1.
Grower Ratings for Possible PTC Benefits

Possible Benefit of Using PTC	Average Rating from 6 Growers*
Reduced pesticide use	2.8
Reduced use of harsh pesticides	2.7
Reduced spray time/expense	2.8
Easier picking/harvesting schedules (reduced REI/dh)	2.9

Reduced personal/personnel exposure to hazards	2.9
Reduced potential for chemical residues at harvest	2.9
Reduced risk from secondary pest outbreaks	2.7
Reduced risk from pest damage/improved crop quality	2.9
Reduced impact on the environment/land/water	2.7
Reduced liability exposure	2.5 (1 N/A)
Improved crop/farm profitability	2.5
Improved public perception/reduced condemnation	2.3 (1 N/A)
Easier/faster pest detection (improved monitoring)	2.9
*Rating: N/A = not applicable, 0 = no benefit, 1 = low, 2 = medium, 3 = high	

All program participants said that they were either very satisfied (60%) or thrilled (40%) with the overall performance of the trap crop system. All final comments about PTC were positive:

- "PTC works well and does its job...the key is you still have to do that scouting."
- "The more I use PTC, the more comfortable I am using it."
- "Perimeter trap cropping works."
- "I highly recommend PTC, especially for big commercial growers...you're crazy not to do it!"

All growers rated the training program as excellent and stated that they would continue using the pepper maggot PTC system in the future.

Implications for Extension and IPM

Despite almost a half-century of IPM research and Extension efforts, pesticide usage continues to rise (Anonymous, 2001; Lewis et al., 1997). Scientists and policy-makers are beginning to express frustration with the lack of progress and are beginning to point the finger at IPM as part of the problem (Anonymous, 2001; Ehler & Bottrell, 2000; Lewis et al., 1997). Yet many Extension IPM programs remain heavily dependent on multiple, full-field pesticide applications as the primary or solitary pest control tactic (Hoffman, 2000). The monitor and spray approach has even picked up a derogatory nickname: "integrated *pesticide* management."

Policy-makers are now calling for future government funding to be tied to true pesticide reductions (Ehler & Bottrell, 2000). These same critics are no longer willing to accept merely substituting one pesticide for another low-use-rate chemical as progress. They want the amount of crop acreage treated with chemicals to be reduced. If Extension and IPM are not viewed as capable of reducing future pesticide use, organizations with more sustainable ideas on pest management may soon become the leaders in agricultural education, with government funding following them.

Critics also fear the consequences of substituting new microbial or biotech products, insect growth regulators, or other selective materials without understanding the potential impact on the biota of the agricultural ecosystem. For instance, Extension specialists often tout the substitution of a selective microbial pesticide (e.g., spinosad) for an older product as an advancement (Burkness, Hutchison, & Pahl, 2000). However, sometimes evidence surfaces at a later time that shows just how detrimental such a material can be to important parasitoids in the cropping systems (Lyon, Van Driesche, Smith, & Lopes, 2002). Critics are calling for a rethinking of Extension's methodology, along with new cropping designs that take advantage of natural preventative measures that can suppress pest populations.

Extension continues to blame low adoption rates for alternative management practices on "conservative grower attitudes" (Hoffman, 2000). Meanwhile, farmers complain that many IPM programs are "too difficult to implement" and that they have limited time for things such as scouting (Hoffman et al. 1997). The fact that it takes an entire book or manual (Boucher & Ashley, 2001) to provide IPM recommendations for a single commodity may help explain the slow adoption of alternative-based programs. Farmers have too much to do and often reach for the quickest or simplest solution to save time and to improve their quality of life. For Extension to increase the adoption rate of IPM programs, we need simpler solutions to problems that are often complex.

Finally, Stephenson (2003) has criticized Extension for relying on outdated versions of the Innovative Diffusion Theory and for targeting innovative new programs at well-educated, wealthier farmers, who tend to be successful early innovators. He cautions that some of our more elaborate solutions may only be applicable to a select group of elite growers and may even harm the disenfranchised portion of our clientele. Extension must design solutions and use delivery methods that are inclusive of the greater farming community, or risk being held accountable for who succeeds and who doesn't.

Summary

Perimeter trap cropping is an example of a redesigned crop production system that helps bring pest populations down to acceptable levels with a minimum of ecological disruption, as advocated by Lewis et al. (1997). This system attempts to minimize disruption from therapeutic approaches, but does not seek to eliminate pesticides entirely. Perimeter trap cropping produces true pesticide use reductions. It is a simpler, cheaper solution that works on multiple crops and pests.

The technology used in PTC is applicable to all growers, not just the better educated or wealthier growers who tend to be early implementors. Perimeter trap cropping involves relatively simple changes in the crop production system that produce substantial advantages. An array of ecologically based solutions must be developed for Extension to maintain its leadership role in the area of pest control in the 21st century.

Acknowledgment

Funding for this project was provided by USDA CSREES NE IPM and NE SARE competitive grant programs.

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