Crop monitoring for early detection of insect pests

Clare Liptak and Dr. Timothy Motis

Editors: Insects and other pests can be a serious constraint to food production, especially where resources for pest management are scarce. For example, in EDN 133 (https://www.echocommunity.org/resources/8a61cb6d-d16e-44b4-9f26-7353b98de322), we responded to a question about problems with tomato leaf miner (Tuta absoluta (https://www.echocommunity.org/resources/69a6f392-8ae6-43dc-b9ed-640e171daf23)) in Nigeria. Heavy infestations of this pest alone can reduce yields by 80 to 100% (Gebremariam 2015). The following article begins an effort to strengthen our informational resources on pest monitoring and management.

General principles and practice

by Clare Liptak, horticulturalist and retired Associate Professor with Rutgers University

What is crop monitoring?

Monitoring is the regular and careful inspection of crop plants throughout the growing season; when monitoring, a farmer walks through his/her crop to look for plant problems such as insects and mites, diseases, weeds, storm damage, and environmental stresses such as drought or nutrient deficiencies. This article focuses specifically on monitoring crops for insect pests.

Why monitor your crops?

Finding problems early gives a farmer time to resolve them before the crop sustains serious damage. With short-term vegetable crops like tomato, early detection of pest problems is critical to enable timely decisions before it is too late. If the pest is not one the farmer recognizes, early detection will mean there is more time to have it identified correctly. Poor monitoring of crops can lead to substantial crop losses.

Monitoring allows for timely and efficient use of pest management inputs. Many insecticides, whether purchased products or farmer-made extracts of various plants, work best—and are less likely to have negative environmental impact--when the pest population is small. Many also work best at a certain stage of pest development. For example, timing of Bt (*Bacillus thuringiensis*) spray applications is critical for controlling pests such as African armyworms (*Spodoptera exempta*). Since the Bt bacterium must be ingested by the target insect, it should be applied when young caterpillars are actively feeding.

It is also helpful to be aware of beneficial insects that could help control a plant pest; see the "References and Further Reading" section at the bottom of this article for links to photos of and information on common beneficial insects. Such knowledge may influence a farmer to adopt practices that favor natural allies against crop pests. For example, if a farmer notices hoverflies (https://www.ctahr.hawaii.edu/organic/downloads/Hover%20Flies%20FINAL.pdf) (Syrphidae family) in the field, they may want to allow flowering plants such as sunn hemp (*Crotalaria* sp.) to flourish around the field (Infonet biovision 2016 (http://infonet-biovision.org/PlantHealth/Natural-enemies), Wang 2012). Hoverfly larvae feed on aphids and small caterpillars, while the adults are attracted to flowers and are good pollinators.

Figure 1. Magnifier with two lenses. *Source: Clare Liptak*

Monitoring tools

Eyesight and an inquiring mind are the most important tools; however, it helps to have the basic items listed below:

- A magnifying glass for observing small insects or insect eggs
- A jar or plastic bag to collect insect specimens for later examination
- Flagging tape or strips of cloth to mark insect-damaged plants
- A pencil and notepad to record observations

I have a magnifier purchased about 20 years ago from NASCO (https://www.enasco.com/product/S07924M). It now retails for $6.85 and has two lenses: one lens (5X) allows me to see most insects, and when using both lenses together (10X) I can see most insect eggs. I've managed to keep it so long because, in the unfolded position, I thread a shoelace through it so I can wear it around my neck while monitoring (Figure 1). In the United States, high quality hand magnifiers made specifically for studying insects cost $30 to $50 from BioQuip (http://www.bioquip.com/). Any magnifying glass will work; cheaper options are likely to be available where office supplies are sold.

Since I am right-handed, I hold the hand lens in my right hand, with the long bone of my thumb on my cheek, so the hand lens is still. Then with the specimen in my left hand, I move it closer and farther away from the lens until the specimen is in focus.

How to monitor?

Regularly walk the entire garden or field

Of course when watering or weeding, farmers are also looking for pest problems, but it is helpful to walk the entire planting or field at least once each week specifically to monitor. Each time a farmer enters their field to monitor, she or he should look for signs of the specific pests that would most likely be there depending on the stage of crop development and time of the growing season. It helps to sometimes enter the field or plot from a different starting point. For example, while walking with the sun at your back, you will see different things than if you always walk facing the sun.

Thoroughly check a few plants

It isn't necessary to check every plant, but check random plants thoroughly in problem areas first, looking at the upper and lower surface of leaves. There may be more than one pest, and the most obvious pest may not be the cause of the plant damage. The number of plants to examine and what to look for varies with the crop and the pest. (OISAT [Online Information Service for Non-Chemical Pest Management in the Tropics] provides a tool (http://www.oisat.org/cropsmap.htm) that lists, for a number of different crops, important insect pests to look for at various crop growth stages.)

Strive for consistency

Personal impressions are the basis for crop management decisions. For example, two people may have different opinions on how many insects constitute a small versus moderate infestation. For this reason, it is best that the same person monitors the crop throughout its development. Alternatively, two people could work together, discussing and agreeing on a monitoring approach before walking the field or garden.

Distinguish between biotic and abiotic problems

Pay special attention to clues that allow you to distinguish pest problems from non-pest, or environmental, conditions. Insects, diseases, mites, rodents, etc. are all biotic, which means "resulting from living things." Environmental conditions such as drought or flooding are "abiotic," meaning they are not caused by living things.

Biotic problems often appear random, especially in the beginning stages—leaves here and there show spots, for example— while abiotic conditions can be very dramatic. An insect problem may start with just a few caterpillars and evidence of feeding damage on a few plants, while droughty soils may cause an entire plant, or group of plants, to wilt or dry up. Biotic problems are also most likely to affect specific or closely related crops. A biotic problem affecting tomato, for instance, would not typically affect maize because those crops are not related. (Tomato leaf miner (http://www.tutaabsoluta.com/tuta-absoluta) is an exception to this general rule, as it not only feeds on plants in the Solanaceae family (e.g., tomato and potato), but has also been found on common beans (*Phaseolus vulgaris*), which are in the Fabaceae family.) In contrast, abiotic problems often affect unrelated crops and even weeds in the same area.

Record observations

In the beginning of the season, draw a map of the field with crops (and even different cultivars of one crop) placed as exactly as possible. This can be used to mark where insect problems occur in the field. Some farmers use a new map to make the notes for each monitoring visit. Others use a separate log for entries. Regardless, for each monitoring visit, note the date and weather conditions, the stage of crop development, and any other information that would be helpful later on in making pest management decisions.

Keep in mind that these notes become the farmer's best tool to increase their expertise; no one will be as knowledgeable about their land as they are. Like anything else, proficiency comes with practice. My early sets of notes were mostly full sentences, no abbreviations, and few observations of the surrounding environment. But in later years, I abbreviated more. *[Editors: If a farmer is unable to write, much can still be learned and remembered through consistent monitoring, and there may be non-literary recording techniques already being used within the community, such as drawing.]*

Use of monitoring traps

by Tim Motis, based on an ECHO trial conducted by Stacy Reader and Christine Paul

Relevance of traps for insect monitoring

Walking through a field to observe pest problems is an important part of any monitoring approach. However, many insects are active at night when it would not be practical for a farmer to be in the field or garden. There are also days when the farmer is away. These limitations are overcome, at least in part, by using any type of container or device that traps enough insects to give the farmer an indication of what pest species are present.

Monitoring traps function day and night and can be made with local materials, such as plastic water or juice bottles. Traps can be placed to target various types of insects. Above-ground traps catch flying insects, before they lay eggs that hatch into larvae/caterpillars that decimate plant leaves. Traps placed at the soil line are good for monitoring ground-dwelling insects hidden in leaf litter or mulch.

How they work

Monitoring traps frequently make use of an attractant or lure. This is often done through the use of colors to which insects are attracted. Yellow objects attract many kinds of insects, including natural enemies of insect pests (Mizell 2014 (http://nwdistrict.ifas.ufl.edu/phag/2014/12/19/tools-for-trapping-pests-and-attracting-beneficial-insects/)). If large numbers of beneficial insects are found in a monitoring trap, reduce the number of traps or try a different color. Other colors commonly used for monitoring traps are blue and white.

Insects can also be attracted to baits that are liquid (e.g., sugar dissolved in water) or solid (e.g., fruit slices or animal dung). Containers are typically filled with water, until 2 cm below the top of the container. Once insects are drawn into a trap, they eventually fall into the water. Add some liquid dish detergent to the water to help prevent trapped insects from escaping. One spoonful (about 15 ml) of dish detergent per container of water should be plenty; use unscented brands to keep smell from skewing the number of trapped insects. As an alternative to using containers, colored pieces of paper or cardboard can be painted with something sticky, like molasses, to capture insects.

Some traps lure specific species of insects with pheromones, which are compounds that insects release to attract a mate, signal alarm, or mark a food trail. Depending on the lure, they can potentially attract insects from far away. Pheromone traps may be available to farmers in some countries, depending on the existence of laboratories that produce the pheromone compounds. This article focuses on traps and baits that farmers can make themselves.

Traps trialed by ECHO in 2016

Many types of traps can be made. For this small trial, we focused on three types:

1) **Dishpan trap**, consisting of a container filled half-way with soapy water made by mixing 30 ml (2 tablespoons) of liquid dish detergent with 400 ml of water. Jugs could be filled and hung on stakes or fruit tree branches. For this trial, we simply placed a round container on the ground.

2) **Pitfall trap** made by filling a container with water and molasses (our traps were filled with 450 ml water + 450 ml molasses + 15 ml of dish soap), with the container buried so that the top of it is flush with the surface of the ground. A banana leaf was placed over the top of each pitfall trap to keep debris from falling in.

3) **Sticky paper traps** made by painting molasses onto a yellow piece of paper from a manila folder (about the thickness of cardstock).

The traps were placed in between rows of sorghum at ECHO's Global Demonstration Farm in southwest Florida. The sorghum plants were close to harvest stage, with a noticeable abundance of insects present. Two of each of the above-mentioned traps were placed in each of three locations in the sorghum plot. Insects were counted after two days; if you wait much longer than that, trapped insects start to deteriorate, making identification and counting more difficult.

Figure 2. Dish pan (left), pitfall (middle) and sticky paper (right) traps used for monitoring insects in a sorghum field at ECHO. *Source: Tim Motis*

Performance of traps trialed by ECHO in 2016

The dishpan traps captured more insects (Figure 3), as well as a greater diversity of insects (Figure 4), than the pitfall and sticky traps. Vrdoljak and Samways (2012) reported that pan traps are a good method for monitoring multiple species of insects. They found that yellow and white pan traps captured a large diversity of insects that visit plant flowers. However, they suggested adding other colors to avoid the possibility of over estimating insects drawn to just one or two colors.

The dishpan traps caught pests such as thrips (species of the Thripidae family) and whiteflies (http://www.infonet-biovision.org/PlantHealth/Pests/Whiteflies)(species of Aleyrodidae family). They also caught beneficial insects including ladybugs (species of the Coccinellidae family; most likely *Harmonia axyridis* (http://animaldiversity.org/accounts/Harmonia_axyridis/)) (Figure 5) and long-legged flies (http://www.nadsdiptera.org/Doid/Dolichar/Dolichar.htm) (species of the Dolichopodidae family), which feed on aphids and thrips. You might catch beneficial insects as well as pest species, but a few small monitoring traps will probably not significantly reduce populations of beneficial insects. Other than pheromone traps, we did not come across any designs that exclude beneficials.

Beetles (not identified to genus and species level) were more consistently captured with the pitfall than the other two trap types. Perhaps pitfall traps could be used in combination with above-ground traps to monitor both ground-dwelling insects and those present in the crop canopy. Whether a farmer uses more than one type of trap or multiple colors of different traps, we recommend a combined approach for reliable and early detection of insect pests.

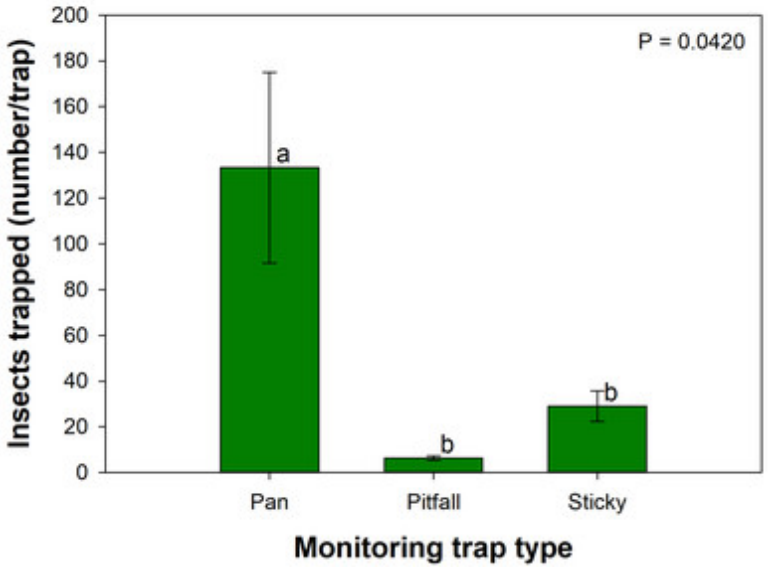

Figure 3. Number of insects captured with dish pan, pitfall, and sticky paper monitoring traps trialed at ECHO in southwest Florida. Data are the average of six replications. Any two bars with a different corresponding letter ("a" or "b") represent statistically different values; those with the same letter represent statistically similar values.

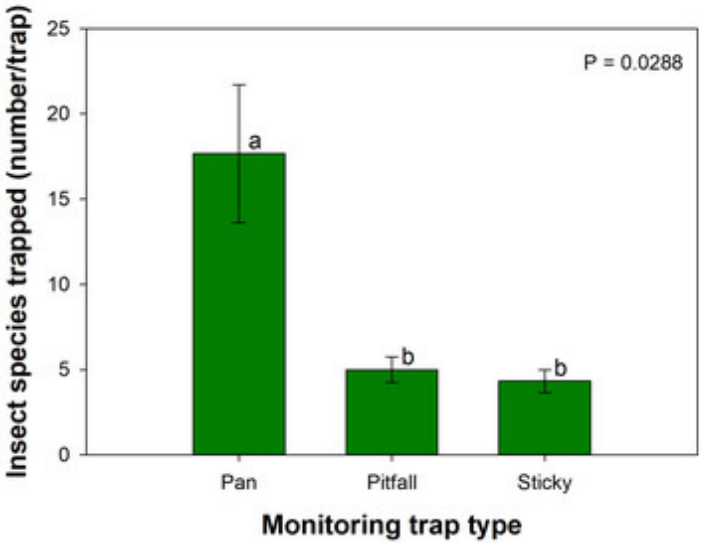

Figure 4. Number of insect species captured with dish pan, pitfall, and sticky paper monitoring traps trialed at ECHO in southwest Florida. Data are the average of six replications. Any two bars with a different corresponding letter ("a" or "b") represent statistically different values; those with the same letter represent statistically similar values.

Figure 5. Ladybug (*Harmonia* sp.) larva (left) and adult (right) observed on sorghum leaves at ECHO in Florida. Note the larva feeding on aphids. *Source: Tim Motis*

Potential improvements

The molasses used with our sticky traps lost its stickiness after the first 24 hours. Boiling the molasses beforehand (to remove water), or adding flour or cornstarch (to thicken it) might help prolong stickiness. We have also learned that used motor oil is often used instead of molasses.

Dishpan and pitfall traps could be covered with screen mesh to keep leaves from falling into them. In our trial, falling leaf litter was not much of an issue. If monitoring traps are being used during the rainy season, a plastic bottle or jerry can might work better than a pan; a 2 to 4 cm-wide slit cut into the side, at least 6 cm above the bottom of the container, would limit exposure to rain drops but still allow insects to enter.

Many other trap designs, placement strategies and baits could be tried. An article by Infonet Biovision, entitled Traps and Bagging (http://infonet-biovision.org/PlantHealth/Traps-and-Bagging), is a good place to look for practical suggestions.

References and further reading

DOCUMENT OR WEBSITE	SUMMARY NOTES
Integrated Pest Management	
FAO (Food and Agriculture Organization of the United Nations) website on Integrated Pest Management (http://www.fao.org/agriculture/crops/thematic-sitemap/theme/pests/ipm/en/).	Links readers to FAO programs related to IPM, as well as IPM-related efforts that the FAO has undertaken in various parts of the world.
UC IPM (http://ipm.ucanr.edu/index.html) (University of California Integrated Pest Management) website.	Contains extensive information on crop pests, pest identification, and insect management. Many of the insects featured on this website are common throughout the world.
Beneficial Insects	
Mizell, R. 2014. Tools for Trapping Pests and Attracting Beneficial Insects (http://nwdistrict.ifas.ufl.edu/phag/2014/12/19/tools-for-trapping-pests-and-attracting-beneficial-insects/). Panhandle Ag e-News (University of Florida IFAS Extension).	Discusses the use of yellow objects to attract beneficial insects.
TECA (Technologies and practices for small agricultural producers) document entitled Beneficial Insects and the Cotton Pests They Control (http://teca.fao.org/read/8677).	Provides photos of common beneficial insects, along with a list of insect pests that they help to control. Insects shown here are often encountered in other crops besides cotton.

References and further reading

DOCUMENT OR WEBSITE		SUMMARY NOTES
UC IPM (University of California Integrated Pest Management) Natural Enemies Gallery (http://ipm.ucanr.edu/PMG/NE/natenemiespest.html).		Presents information on natural enemies of various insect pests.
Wang, K.-H., 2012. Cover Crops as Insectary Plants to Enhance Above and Below Ground Beneficial Organisms (https://www.ctahr.hawaii.edu/sustainag/news/articles/V11-Wang-insectary-covercrops.pdf). Hānai'Ai/The Food Provider.		Provides insights in how to integrate flowering cover crops into farmers' fields for the purpose of attracting beneficial insects.
Lingbeek, B.J., CL. Higgins, J.P. Muir, D.H. Kattes, and T.W. Schwertner. 2017. Arthropod diversity and assemblage structure response to deforestation and desertification in the Sahel of western Senegal (http://www.sciencedirect.com/science/article/pii/S2351989417300598). Global Ecoloogy and Conservation 11:165-176.		This paper is authored by former ECHO intern and staff member, Brandon Lingbeek. It sheds light on the use of pitfall traps to monitor insect diversity in the Sahel. Section 2.2 explains how their pitfall traps were designed and implemented.
Insect Pests and General Information		
Gebremariam, G. 2015. Tuta Absoluta: A Global Looming Challenge in Tomato Production, Review Paper (http://www.iiste.org/Journals/index.php/JBAH/article/download/23987/24558). Journal of Biology, Agriculture and Healthcare 5(14):57-62.		A review of the literature on tomato leaf miner.

References and further reading

DOCUMENT OR WEBSITE		SUMMARY NOTES
Infonet biovision (http://infonet-biovision.org/) website.		Contains a wealth of information on pest control, covering approaches including natural enemies, neem extracts, soap spray, garlic and neem extracts, and insect monitoring traps. On the home page, find and click on "Plant" or "Plant Health" to find information about crop pests and management approaches.
OISAT (http://www.oisat.org/home.html) (Online Information Service for Non-Chemical Pest Management in the Tropics).		Lists pests affecting specific crops, with links to photos and additional information about insect pests and ways to control them. Also has information on crop diseases.
TECA (Technologies and practices for small agricultural producers) document entitled Pest and Disease Management in Organic Agriculture (http://teca.fao.org/read/8372).		A section on crop monitoring explains what to look for as far as crop damage caused by insects. There are also sections on insect monitoring traps and ways to enhance natural enemies of insect pests.

References and further reading

DOCUMENT OR WEBSITE		SUMMARY NOTES
Vrdoljak, S.M. and M.J. Samways. 2012. Optimising colored pan traps to survey flower visiting insects (https://www.researchgate.net/publication/227259185_Optimising_colored_pan_traps_to_survey_flower_visiting_insects). Journal of Insect Conservation 16(3):345-354.		A research report on pan monitoring traps that promotes multiple colors and contains a thorough review of literature pertaining to pan traps.