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ECHO Development Notes

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## INSECT PEST MANAGEMENT: OPTIONS FOR CONTROLLING PESTS

*This article explains some principles and practices for controlling pest populations through diverse strategies.*



## EVERGLADES (WILD) TOMATO

The wild tomato (*Solanum pimpinellifolium*) is a different species than the standard tomato (*Solanum lycopersicum*). It produces many bunches of tiny fruit on large, sprawling plants.



## ACACIA ANGUSTISSIMA FARMING IMPROVEMENT EXPERIENCE

*ECHO network member Paul Noren shares his experience promoting a unique agroforestry rotation in Congo, Central Africa.*



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ECHO  
17391 Durrance Road  
North Fort Myers, Florida 33917  
USA

Editorial Team:

Managing Editor: Tim Motis

Design Editor: Stacy Swartz

Proofreaders: Bob Hargrave and Cody Kiefer

Content Specialists: Annie D., Andy Cotarelo, Noah Elhardt, and Jason Weigner

# Insect Pest Management: Options for Controlling Pest Populations

by Stacy Swartz

Part 3 of 4 in a series about Integrated Pest Management (IPM)

One of the most critical decisions a farmer makes during a growing season is how to effectively control pests to preserve the productivity and economic value of a crop. A farmer's reaction to seeing pests in their crops or grain is to intervene to protect his or her livelihood. The first two articles in this IPM series focused on [preventative pest management](http://edn.link/prevent) [http://edn.link/prevent] strategies and [observing pest populations](http://edn.link/ipm2) [http://edn.link/ipm2] to determine when to intervene. This article will discuss suppressive strategies to reduce pest populations once you have decided to intervene (Figure 1). The last article in this series will address how to evaluate and assess strategies used and ways to improve your IPM plan over time.

## Potential Constraints

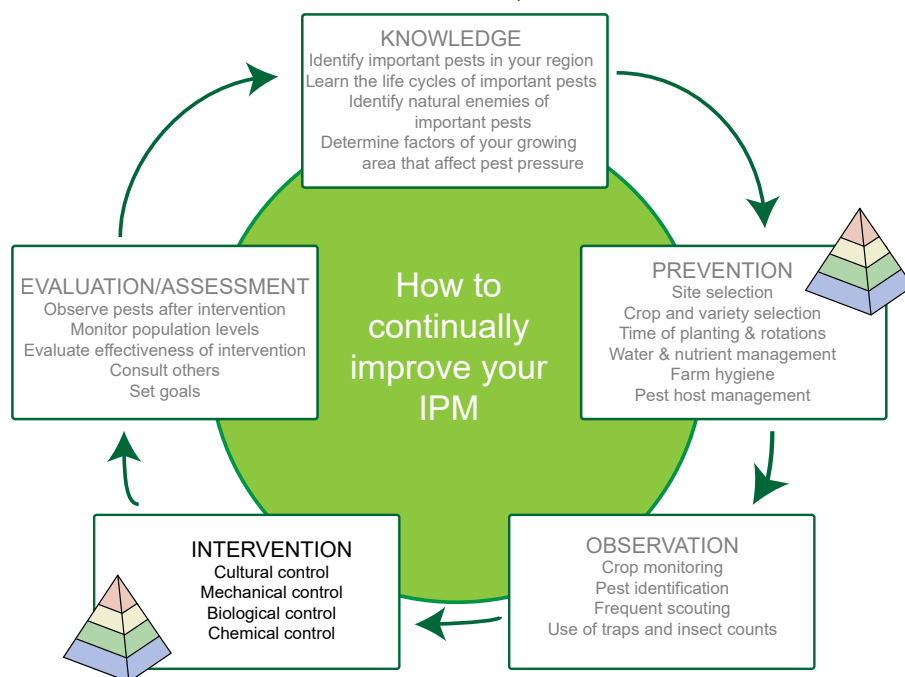
Many regionally-practiced intervention strategies for controlling pests exist, but information is limited on which practices are effective against

specific pests and under what conditions. Tesfaye and Gautam (2003) reviewed 26 traditional pest management practices used in India and Ethiopia, many of which need validation or revisiting. There is a great need for additional evaluation of locally-practiced pest control methods and the adaptation of effective pest control methods to regional contexts.

Network member Jason Weigner shared:

Anyone working with local farmers should spend time asking about local pest management techniques. Odds are you'll find things that don't really work, but you may also find some real gems. I have been researching and experimenting with ways to control leafcutters for years.

Unfortunately, many things I've come up with are expensive, time consuming, or involve chemicals. Then one day I was walking with a Bolivian guy I work with looking at trees that had been defoliated by leaf cutter ants yet again and he casually said "We need to get some cotton." The moment he told me about wrapping the trunks with cotton it made total sense. They get tangled in the cotton fibers, so they go hunting elsewhere. Such a simple and inexpensive solution found locally.



**Figure 1.** Stages of an example IPM cycle. Planning can start at any stage of the cycle, and the order of stages is flexible. The pyramid icon indicates strategies that prevent or suppress insect pests. Source: Adapted from [farmbiosecurity](https://farmbiosecurity.org/), Creative Commons Attribution 3.0 license

Perceptions of different control methods vary from one region to the next. Where synthetic insecticides are available and accepted, farmers are not always informed about the proper mixing and handling of pesticides, disposal of pesticide containers, and use of personal protection equipment (PPE). Moreover, pesticide handling and regulation efforts are not always consistent or enforced.

Constraints such as these will shape how farmers intervene to control pests. The remainder of this article will discuss intervention options that may help control pest populations.

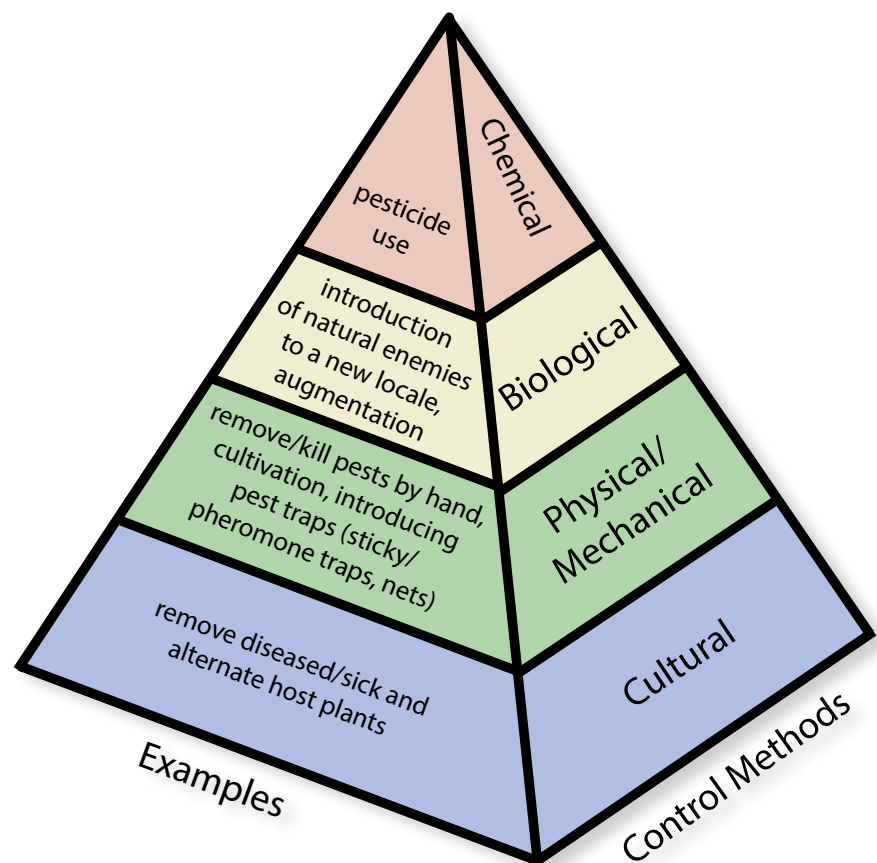
## Intervention Options

Always prioritize pest control options that fit the local context and utilize locally-available resources. If an intervention requires resourcing from outside the community, you should first consider other alternatives. Try to establish systems that will ensure long-term access and availability of these resources. You may need to:

- support local entrepreneurship,
- create a plan for area-wide management of the pest so that the burden falls on the whole community instead of individual farmers, or
- set up systems for governmental or organizational support.

Additionally, evaluate whether a practice will be culturally appropriate. Seek opinions and feelings of those in the community who might be affected by the pest management plan.

When selecting pest control options, utilize interventions that are effective, have the least impact on the surrounding community and environment, and are complementary when integrated. When information for a specific species or crop is not available, you may need to trial potential strategies in a small area to determine which one is most effective. At times, normal seasonal changes are sufficient to keep diseases or pests in check, with no intervention other than adjusting the timing of planting. For example, diseases that flourish under humid conditions may all but disappear during the dry season. This article overviews suppressive options for situations that require intervention in response to observed pests or diseases. Pest control options are discussed under the categories mentioned in figure 2.



**Figure 2.** Control method categories (right) and example strategies (left) for suppressive pest control. Source: Stacy Swartz



**Figure 3.** Potted tomato plant with minimal leaves remaining, especially at the base.  
Source: Stacy Swartz

## Cultural options

Cultural controls modify the environment around the plants to make it less favorable for pests. Pests in your main crop(s) may also be harbored/hosted by other species of plants growing in or near your field or garden. Removing or pruning these alternative host plants can help minimize the pest population. If using biological control as well, preserve--as much as possible--trees, shrubs, or weeds near your crop that natural predators use for refuge, food, and nesting. You can also use cultural practices on your main crop (Table 1). Tomato plants, for example, can be managed to minimize bacterial and fungal diseases. Humidity in the leaf canopy is highest around leaves closest to the ground, which is why these water-transmitted diseases typically infect the lower leaves first and then spread upwards to the rest of the canopy. When you remove lower tomato leaves, you reduce humidity near the soil surface by increasing airflow (Figure 3). Doing so early in the season reduces early-season development of diseases.

**Table 1.** Practices, description of practices, and specific examples of cultural interventions.

Strategy	Description	Example
Remove diseased parts/ individuals	With sterile tools <sup>1</sup> , prune plant parts (leaves) or whole plants that are heavily diseased or infested.	For Cucurbita (e.g., pumpkins) with excessive downy mildew damage, you can remove leaves that are heavily infested and feed them to animals. Do not mulch with them as the pathogen may still spread.
Remove alternative host plants	With sterile tools <sup>1</sup> , remove alternative host plants that are heavily diseased, infested, or that host vectors.	If you are growing citrus, remove curry leaf tree ( <i>Murraya koenigii</i> ) or jasmine orange ( <i>Murraya paniculata</i> ), which are hosts of Asian citrus psyllids that spread citrus greening disease (Gast et al., 2018).
Use of efficient irrigation systems	To reduce water-transmitted diseases, irrigate according to plant needs and direct water to the base of plant stems.	Switch from overhead irrigation (which gets leaves wet) to drip irrigation or hand watering at the base of plants. Support plants with stakes or trellising to minimize contact of plant leaves with moisture on the soil surface.

<sup>1</sup>Tools can be sterilized with isopropyl alcohol, vinegar, bleach, or high heat to kill pathogens that may be on the tool from previous use.

## Mechanical/physical options

Mechanical interventions for pest control are generally categorized as passive or active. Passive options include films, dusts, oils, soaps, and traps. Films such as kaolin clay (Figure 4) can deter insects from landing on plants and/or deter feeding behaviors, but such films need to be reapplied as the plant generates new growth. Dusts such as diatomaceous earth can be placed around the base of plants to keep crawling pests from accessing the plant. Dusts can also be placed on the leaves as a feeding deterrent. Oils and soaps that kill pests are physical controls because their effect is short-term, and they act physically on the pest by smothering them or breaking down sensitive exterior tissues. Oils and soaps must contact pests and are most effective against soft-bellied insects such as aphids, mealybugs, whiteflies, spider mites, and scales. Repeated application is often required to control a population because oils and soaps are most effective at controlling young individuals. Traps are mainly used to monitor pests but can have applications for reducing pest populations (Table 2). Control of large or dense populations is difficult with traps.



**Figure 4.** Kaolin clay sprayed on a potted tomato plant.  
Source: Stacy Swartz

Active mechanical control options include hand-picking and removing pests, vacuums or blowers (pneumatic), and hot water immersion. Picking pests off your plants by hand works well for small areas. Jason Weigner shared that:

This is a great job to get local kids to help with. I was asked in an Ayore village to help with blister beetles that were eating all their hot peppers. There were few enough bushes that we were able to get them under control quickly by turning it into a game with the kids. We made beetle grabbers out of coke bottles with soapy water in the bottom and it was a race to see who could catch the most!

You can pull or squash caterpillars by hand. Beetles, stink bugs, and other larger insects can be put into a bucket of soapy water. The soap breaks the water tension, causing insects to drown in the bucket (Figure 5). Low-tech vacuums suck pests off plants into holding containers that are later dumped into soapy water; this method is mostly used to collect specimens for pest identification. Hot water immersion effectively kills immature tephritid fruit fly (Diptera: Tephritidae) inside mango fruit (Vincent *et al.*, 2002).



**Figure 5.** A bucket of soapy water with leaffooted bugs (Hemiptera). Source: Annie D.

**Table 2.** Practices, description of practices, and specific examples of mechanical interventions.

Strategy	Description	Example
Picking (by hand)	Pick insects by hand and put them into a container of soapy water or shake them from the plant directly into the container.	Stink bugs (Pentatomidae family) damage tomatoes, rice grain, and much more. Handpick adult stink bugs in the morning, while they are sluggish. This practice can help decrease populations if implemented early (soon after stink bugs are detected).
Cultivation	Weeds are removed by scratching the soil surface with a tool. The tool either cuts the shoots from the roots of the weeds or completely buries the weeds.	A <a href="#">stirrup</a> or <a href="#">scuffle</a> hoe is used to cut weeds off just below or at the soil surface.
Traps	Traps are often used for monitoring but can also be used to control pest populations in smaller areas by removing specific life stages of the pest or reducing overall numbers.	<a href="#">Sticky traps</a> in nursery or greenhouse settings can help control whitefly populations if installed early when the population is small. These are only effective against adult whitefly.
Other mechanical modifications	Altering the environment around plants or seeds can kill certain life stages of pests or whole pest populations.	Consider: Solar heating for cowpea weevil ( <i>Callosobruchus maculatus</i> ; ECHO Staff, 1992).

There are also mechanical/physical techniques for managing pests and diseases in stored seed or grain. Polishing grains to remove the outer seed coat with mechanical mills helps remove pests prior to storage. Once in storage, keeping grain in sealed containers excludes pests and humidity; dry conditions prevent the growth of mold. You can also lower or replace oxygen to physically modify the environment in sealed storage containers, killing storage pests or minimizing the damage they cause. Techniques such as vacuum and replacement of oxygen with carbon dioxide are reviewed by Motis (2020) in [EDN 146](#) [<http://edn.link/lowoxygen>].

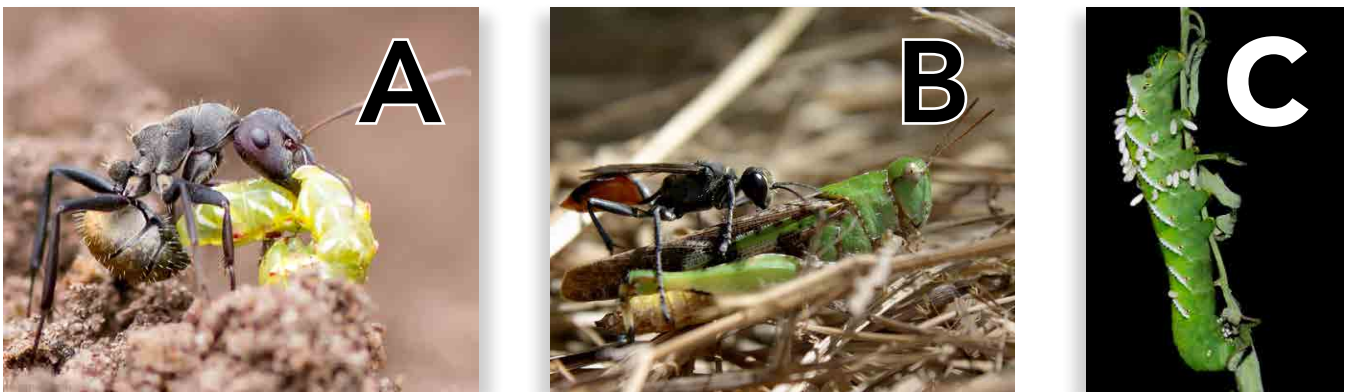
### Biological options “add to the answer”

Biological control reduces pests through the management of other living organisms. Biological approaches to pest control are ecologically sound, environmentally safe, and self-perpetuating. Most natural predators are species-specific and, therefore, not a threat to non-target species such as [pollinator species](http://edn.link/6ryxxy) [http://edn.link/6ryxxy]. Lastly, biological control brings stability to an agroecosystem over time; this happens as pest populations are reduced, fluctuations in pest populations are moderated, and fewer interventions are needed. Biological control alone is not likely to solve a pest problem. Rather, it supplements other control strategies, supporting long-term effectiveness of an IPM plan.

Natural predators are likely already present and active in your region. You can add a biological component to your IPM strategy by simply enabling these predators to thrive. For ideas on how to attract and sustain natural predators in your garden, read the [habitat management](http://edn.link/i#habitat) [http://edn.link/i#habitat] section of the pest prevention article.

You can also re-introduce natural predators that are native to an area but have left the region. This process, called augmentation, is easiest to implement if supporting habitats already exist that can sustain natural predators year-round; without such habitats, the farmer must purchase and release native predators each season. The introduction of non-native predators to control local pests is called classical biological control and is too expensive and risky for most smallholder contexts. Check with local extension services to see what programs exist and what predators are available for distribution and release. Typically, government agencies, educational institutions, or other organizations are responsible for native or exotic predator research and rearing (Table 3).

Beneficial organisms actively hunt and kill pests for metabolic or reproductive needs. Beneficial predators include many species of ants that consume young caterpillars (Figure 6A), aphids, and other soft-bellied insects. *Prionyx* wasps hunt and consume grasshoppers (Figure 6B). Beneficial parasites, known as parasitoids, deposit eggs inside a pest, eventually killing the pest (Figure 6C). The most well-known group of parasitoids are the very diverse parasitic wasps. Each species of parasitic wasp lays its eggs inside a highly specific host, which could



**Figure 6.** Carpenter ant (*Camponotus sericeus*) preying on a caterpillar (A) and predatory wasp (*Prionyx* sp.) preying on a grasshopper (B). Parasitized hornworm caterpillar. White, fluffy protrusions are parasitoid egg sacs (C). Source: Noah Elhardt (A & B) and Jason Weigner (C)

be a soft-bellied insect such as an aphid or caterpillar or even a hard-shelled beetle. For every crop pest, there is likely at least one parasitoid targeting it. Van Lenteren *et al.* (2018) outline the use of many diverse species for biological control worldwide.

**Table 3.** Practices, description of practices, and specific examples of biological interventions.

Strategy	Description	Example
Natural predators	A farmer keeps a few host plants for pests, plants that feed adult natural predators, and/or plants that house natural predators to encourage local populations.	Plant a few sunflowers in the off-season, which stink bugs will move to from your crop, encouraging soldier bugs (and other natural predators) to stay in the area.
Augmentation	An entomologist goes looking for native natural predators or parasitoids that are no longer in the region and brings them back.	Purchase or apply for parasitic wasps that have been reared by a local university, research center, or government agency. Once obtained, you can release them in your production area. An example of a gardener practicing augmentation was shared by network member Noah Elhardt. <sup>1</sup>
Classical biological control	An entomologist looks for non-native potential predators or parasitoids that, when introduced, may control the pest. Researchers rear potential insects, test their propensity to be invasive, and rule out predators that are not good candidates.	Introduction of the predatory wasp ( <i>Tamarixia radiata</i> ) to help control the Asian citrus psyllid nymphs (Michaud, 2004). This is typically too expensive an endeavor for farmers or even co-ops of farmers to conduct.
Microbial disruptors of midgut	Microbes that, after being consumed by a pest, produce protein toxins that create holes in the midgut of the pest.	Some <i>Bacillus</i> sp. are commercially sold in many places around the world and can be applied through a foliar application. Pests then consume the bacteria as they eat crop tissue.
Insect-killing fungi	Some fungi are entomopathogenic, meaning they parasitize and complete their life cycles on pest species.	The fungus <i>Ophiocordyceps unilateralis</i> completes its life cycle on only one species of formicine ant ( <i>Camponotus leonardi</i> ), making a mummy out of the ant's exoskeleton (Shang <i>et al.</i> , 2015).

Biological control is a long-term investment. Parasitic wasps, for example, will not control active caterpillar populations by themselves, but they reduce numbers in future generations. That is why biological control is a vital part of IPM.

## Chemical options

Chemical options, as we refer to them in this article, are those that actively work against pests through substances that are toxic to or that repel pests. Chemical control methods include both natural and synthetic pesticides.<sup>2</sup> The active ingredient in a pesticide is the portion that is toxic or repellent. The remainder of the pesticide is inert ingredients. It is possible to select natural and/or synthetic insecticides that are “biorational” in the sense that they target specific pests, have minimal impact on the environment, and have low to no toxicity on non-target species.

## Mode of action

The mode of action of a chemical intervention describes how a pesticide, whether natural or synthetic, controls the pest. Basic modes of action are summarized in Table 4.

<sup>1</sup> Being observant can sometimes lead to inexpensive opportunities for augmentation. Noah Elhardt shared a story about a gardener who noticed that the aggressive termites that were causing problems in his gardens were preyed on by an ant species (*Megaponera analis*) living in the forest nearby. The gardener cleared trails from the forest population directly into his gardens, successfully inviting ant raids to enter his garden and overcome the termites.

<sup>2</sup> Similar terms used are organic and commercial, but for the sake of this article, we will stay with natural and synthetic because there are organic pesticides that are both natural and synthetic, but natural and synthetic categories don't overlap.

**Table 4.** Mode of action descriptions and examples for a generalized list.

Mode of action	Explanation	Synthetic example(s)	Natural example(s)
Inhibitors	Inhibit pest growth, enzyme synthesis, molting, creation of chitin, or other important metabolic pathways	Organophosphates Methyl bromide Carbamates	Decaleside (from <i>Decalepis hamiltonii</i> ) and Rotenone (found in many plants, including <i>Tephrosia vogelii</i> )
Channel blockers	Block channels in neurological pathways or other important metabolic channels (e.g., sodium)	Indoxcarb	Tetrodotoxin (from <i>Taricha granulosa</i> )
Modulators	Keep neurological or metabolic systems open, often causing imbalances in one or more senses; a common result is disrupted feeding	DDT Neonicotinoids Pyrethroids	Pyrethrin Nicotine Capsaicinoids (in hot peppers)
Juvenile hormone mimics	Disrupt and prevent metamorphosis	Analogues of juvenile hormones	Some <i>Echinacea</i> spp. mimic adult hormones
Unknown	The mode of action for some pesticides is still unknown Some pesticides have more than one mode of action		Azadirachtin (in neem, <i>Azadirachta indica</i> )

③ Pesticide resistance is a gradual process wherein a pest population becomes less susceptible to a pesticide that was once effective.

When creating a pest management plan, select pesticides with different modes of action and time their application to vary the mode of action. Diversification of modes of action increases the likelihood of controlling whole pest populations (e.g., all life stages) and prevents pesticide resistance.③ Categories, descriptions, and examples of chemical interventions are given in table 5.

**Table 5.** Categories of chemicals, description of chemicals, and specific examples of chemical interventions

Strategy	Description	Example
Natural chemicals	Chemicals extracted from natural sources. These are not always the safest and may still require PPE for application and restrictions on where and when you can use them.	Azadirachtin is extracted from neem seeds and leaves (at a lower concentration) and applied to crops to control a variety of pests, mainly piercing-sucking insects.
Synthetic chemicals	Manufactured chemicals. These may be more toxic or less toxic than natural chemicals.	Pyrethroid is a manufactured compound that mimics natural pyrethrins (naturally produced by chrysanthemum flowers).
Targeted chemicals	Chemicals specific to a species or group of insects. Such chemicals do not impact organisms outside of a narrow range of target species.	Chlorine containing carbamates such as RynaXypyr® target immature Lepidoptera, but not other insect groups.
Broad spectrum chemicals	Chemicals that broadly affect more than just the pest species you are trying to control.	Pyrethrins and pyrethroids kill ants, mosquitoes, moths, flies, fleas, and impact other organisms, including bees and fish.
Preventative application	Chemical application before a pest has been identified and sampled. Be cautious in using preventative applications as they may lead to pesticide resistance over time due to frequent exposure of the pest to the chemical.	Application of imidacloprid, a systemic pesticide (absorbed and distributed throughout plant tissue) before any pest presence is identified to ensure control of the Asian citrus psyllid, a vector for citrus greening disease (Gast <i>et al.</i> , 2018)
Reactionary application	Chemical application after a pest has been identified and sampled.	Application of imidacloprid after a pest the chemical is approved for controlling (mainly piercing sucking insects) is observed.

## Safety

When using any pesticide, whether natural or synthetic, it is vital to follow correct mixing and loading practices, wear correct PPE, and practice safety measures during application. Pesticide product labels should explain the PPE required for unique settings<sup>4</sup> that have distinct PPE recommendations. Product labels should also include any specific health risks corresponding to the product and instructions for how to decontaminate potential spills. Pesticides are sometimes repackaged and sold without labels. If a product does not have a label, try to look up the information with the product and company name, active ingredient, or commonly used name. Refrain from using a pesticide product for which you do not know the name, active ingredient, and potential health risks. Pesticide use without this information is unsafe.

Only use pesticides that are known to be effective on the target pest and apply them at a rate consistent with effective control for that pest. Application rates that vary from recommendations can cause issues with pesticide resistance, environmental contamination, or increased toxicity.

When applying pesticides, there are important factors to be considered:

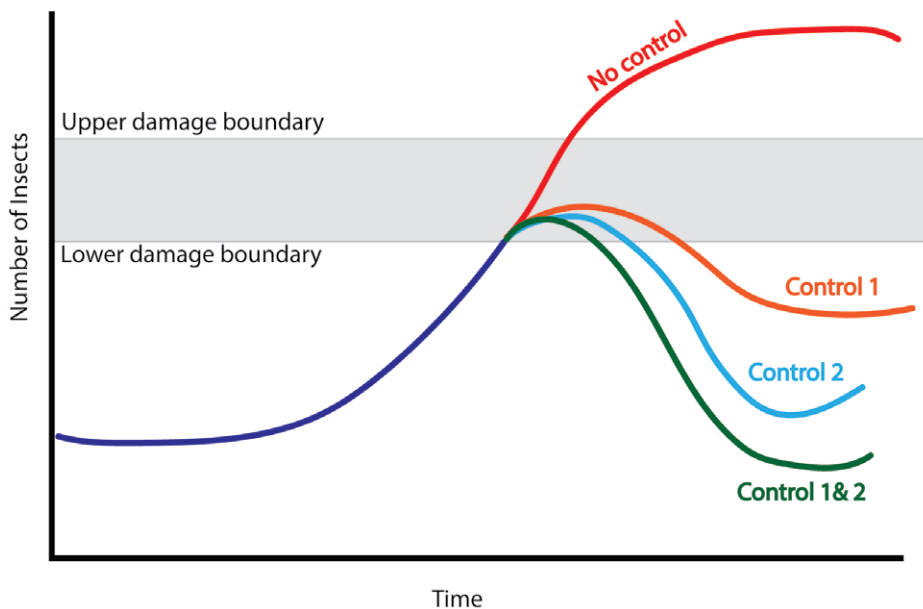
- **Temperature** - Avoid spraying pesticides at air temperatures above 30°C, which can burn plant parts. Instead, apply in the early morning or evening when the temperature is lower, and the sun's rays are less direct.
- **Wind** - Do not apply pesticides if there are gusts or consistent wind speeds above 16 kph (10 mph). High wind speed causes your spray to drift into surrounding areas causing damage to non-target organisms, creating a safety issue, and reducing the accuracy of your application.
- **Rain** - Rain washes off and dilutes many pesticides. Do not apply them if it will rain soon. If it has rained shortly after an application, pay close attention to your crops to determine if reapplication may be necessary.
- **Plant physiology** - Younger plants are more sensitive to pesticide burns than older plants. Pesticide burns are most likely to occur when the sun's rays are most direct, and when oils are used. If applying a pesticide with oil in it, spray early in the morning or in the evening. Flowers are more sensitive to pesticides than other plant parts, so try not to apply foliar pesticides when flowers are open.
- **Proximity to water bodies** - Many pesticides, whether natural or synthetic, negatively impact aquatic or semi-aquatic ecosystems. If you are close to water bodies, observe extra precautions to avoid spray drift, pesticide runoff (can occur if it rains shortly after spraying), or overapplication (can cause leaching into groundwater).
- **Effect on target species** - It is important to know how a pesticide impacts the target species. It may only kill or repel a specific life stage of the pest and therefore may need to be reapplied later to effectively control a population. For example, eggs are the most challenging life stage to control, and therefore you may need to reapply a pesticide once eggs of the previous generation have hatched.

<sup>4</sup> PPE recommended may be different during mixing of pesticide vs. application or may be different if you are applying in a nursery vs. field setting. Make sure to read labels carefully.

- **Effect on non-target species** - It is essential to understand how a pesticide may affect non-target species. This consideration is important if you are hoping to create long-term health and balance in your agroecosystem. If there are harmful effects on pollinator species, biological control agents, or other organisms that are desirable in your agroecosystem, reconsider your use of the product; explore other alternatives or apply to plants before they flower (to avoid harming pollinators).
- **Timing and frequency of application**- Many natural pesticides are less effective than synthetic pesticides. Therefore, some natural pesticides need to be applied when pest populations are low and be applied frequently to ensure the pest population stays within acceptable levels.

If you apply a pesticide that may harm people and animals, communicate with local community members to ensure that everyone knows when and how long they need to stay out of the area. Commercial pesticides have published restricted entry intervals (REIs) that indicate when it is safe to re-enter the sprayed area.

### Integration of interventions



**Figure 7.** This diagram shows how different types of control strategies could impact a pest population. Control 1 doesn't reduce the population as much as control 2, but lasts a bit longer in its effectiveness. Combining both controls may have an even greater effect in reducing pest population. Source: Stacy Swartz

Cultural, mechanical, biological, and chemical intervention options should be leveraged when they are most appropriate for your context, crop needs, and level of damage. Select practices from each category that fit your needs, resources, and comfort. It is unlikely that any one practice can effectively control pests while maintaining long-term sustainability. Therefore, it is best to integrate your pest management approach with a variety of strategies that trap, repel, and reduce pests in unique ways (Figure 7). Damage boundaries also vary based on the control measures available. Jason Weigner shared a caution about suppressing pests to levels that will not sustain natural predator species:

[Reducing] the pest population too low could lead to the predator dying off or moving on [to another area], which then leads to worse pest spikes in the future.

An example of an IPM approach for dealing with sugarcane white grub in Bali, is described in [Asia Note 42](http://edn.link/qt6hxx) [http://edn.link/qt6hxx]. Start by considering practices at the base of the pyramid (Figure 2) and work your way up if possible. If there is too much damage already done,

this may not be possible, and you may have to start with stronger suppressive steps. Next season, try to invest time earlier in the season to implement cultural, mechanical, or biological options.

## Conclusion

IPM is an approach to managing pests that combines different strategies, each one functioning in a unique way. Continuously improving your pest management plan requires dedication to learning about pests, observing them, and evaluating the effectiveness of your prevention and intervention actions to limit or control pest populations. In the last article, we will overview how to evaluate intervention strategies, assessing their effectiveness, and then adjust future pest management plans.

## Further Reading

To learn more about natural pest control options, explore [oisat.org](http://oisat.org) [<http://edn.link/rxj2dy>], where you can navigate resources by pest, crop, or control method.

The USDA has a section on “Problem Prevention and Holistic Pest Management” specific to tropical nurseries starting on page 273 of their *Tropical Nursery Manual: A Guide to Starting and Operating a Nursery for Native and Traditional Plants* [<http://edn.link/2mtf7j>].

Rapisarda and Cocuzza’s *Integrated Pest Management in Tropical Regions* [<http://edn.link/7x933r>] book published by the Centre for Agriculture and Bioscience International is a valuable resource. The book goes deep into practices, integration of control options, and specific constraints in tropical conditions, including the unique impacts of climate change on pest management.

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## From ECHO's Seed Bank: Everglades (Wild) Tomato

by Holly Sobetski



**Figure 8.** Fruit of wild tomato.  
 Source: Tim Motis

The wild tomato (*Solanum pimpinellifolium*) is a different species than the standard tomato (*Solanum lycopersicum*), though the two species are cross-compatible, meaning they can cross-pollinate and produce viable offspring. Wild tomatoes produce many hands/bunches of tiny fruit (Figure 8) on very large, sprawling plants that live up to their name.

The bite-sized fruit has soft skin and is easily added to salads, requiring no processing. The fruits are known for their rich flavor. Wild tomato fruits are easy to harvest, with minimal damage to the skin. Wild tomato is a good option for hot, humid conditions. Most cultivated tomatoes are susceptible to diseases, especially in hot, humid weather. Spraying and using disease-resistant varieties is often necessary to produce a good tomato crop with standard varieties. The wild tomato, however, is naturally disease and heat resistant, so it performs well even when standard tomatoes would struggle.

Wild tomato is an excellent addition near a house or on the border of a field, as it is perfect for harvesting and eating out of hand when you are hungry. It is an open-pollinated heirloom, and you can save the seed from year to year.

### Tradeoffs

One of the tradeoffs of wild tomato is that the plants are large and take up a lot of space. One plant can grow to a diameter of 3.6 m if left unmanaged. They are not suitable for a small garden with limited space, so we recommend planting them along a fence line, in an area where they can sprawl, or on a raised bed with a trellis.

The next tradeoff can also be a benefit. Because wild tomato and standard tomato are cross-compatible, genes of wild tomato can mix with those of other tomato varieties flowering at the same time and grown too close together.<sup>5</sup> This crossing would only be an issue if you are saving the seeds and want the tomato varieties in your garden to remain pure. On the positive side, you can cross local tomatoes with wild tomato to introduce disease resistance. A project like that takes time and requires careful observation. Genes related to fruit quality and plant growth will mix, so you would need to record specific characteristics observed in subsequent generations and save seeds from plants with desirable traits.

Another tradeoff is that the fruit does not last long off the vine and does not travel well. It is best to consume fruit during the first day or two after harvest.

Lastly, the plants often reseed themselves, from fruits that drop to the ground or are spread by birds. Remove unwanted volunteer seedlings.

### Cultivation

I seed and plant the wild tomato at the same time as standard tomatoes for my area. However, you can plant them a few weeks earlier and a few weeks later than usual in subtropical and tropical climates to extend the

<sup>5</sup> In saving seeds for personal/home use, and wanting to keep varieties pure, keep wild tomato varieties at least 12 m from plants of other tomato varieties (McCormack, 2004). If distributing seeds to others, increase that distance to at least 23 m.

growing season. If planting in a temperate climate, I would plant them during the typical tomato growing season, and they should continue to bear fruit for an extra month or two after the regular growing season. It takes about 90 days to obtain the first harvest of fruit after planting seeds.

Sow seeds into nursery beds, small containers, or trays for starting seedlings. When the resulting seedlings have three to five leaves, transplant them into the garden 1 m apart within rows and 2 m between rows. This spacing might seem excessive, but it is not; they need a lot of space.

Wild tomato plants need water, especially as they are getting established, and fertile soil amended with phosphorus will increase productivity. We have also had volunteer wild tomato plants appear along fence lines that did great without any watering or fertilizing on our part. So, the plants do better when watered and fertilized, but they can also grow without much attention and input.

If you want to make the fruit more accessible and minimize disease problems, support the plants with a trellis (Figure 9). Keeping the canopy above the ground helps keep the leaves dry, preventing diseases that spread rapidly under wet conditions. Wild tomato has many side branches but trellising in a weave pattern<sup>6</sup> helps keep the main plant supported so that fruit is visible. The plants will engulf tomato cages, making them unsuitable as supports. You can also let plants go unmanaged, but they will need more space to crawl and sprawl since they will not be encouraged to grow upwards.

## Seeds

Active development workers who are members of [ECHOcommunity.org](https://www.echocommunity.org) may request a trial packet of seed. (See [the website](https://www.echocommunity.org) for how to register as a member and how to order seeds.)

## Reference

McCormack, J.H. 2004. [Tomato seed production](https://www.savingourseeds.org): an organic seed production manual for seed growers in the Mid-Atlantic and Southern U.S. [www.savingourseeds.org](https://www.savingourseeds.org). Version 2.6 [NOTE: The manual summarizes factors affecting the distance over which cross-pollination of tomatoes can occur. A companion manual entitled 'Isolation Distances', also found at [www.savingourseeds.org](https://www.savingourseeds.org), provides more in-depth information on keeping seed varieties pure.]



Deforestation, overused soils, increasing competition for land, and climate change have made subsistence farming in much of Central Africa a precarious occupation. Malnutrition is on the rise, and local economies have declined in many places. The use of leguminous trees in agroforestry systems addresses these problems.

While working on various agricultural projects in Northwest Congo in the mid-1980s, we worked with a young farmer group in Botolofionamed "Tembe na Mbeli," an idiom in Lingala for "Don't doubt the power of a machete." These young men were out to prove that a good machete and



**Figure 9.** Growth habit and size of wild tomato. Source: Tim Motis

<sup>6</sup> Weave trellising involves passing strings on either side of the plant as it grows, containing the plant between the strings of the trellising. Weaving usually starts when plants are 75-90 cm tall and additional strings are added as the plants grow upward. Stakes in-row with plants anchor the string.

## Echoes from our Network: *Acacia angustissima* Farming Improvement Experience

by Paul Noren



**Figure 10.** Grassland (left) before growing maize with *Acacia angustissima* (right). Source: Paul Noren

a willing spirit could accomplish something worthwhile. The tall tropical forest that once characterized the area years ago had become open grassland dominated by *Imperata cylindrica*, a tough sword grass that thrives in areas with poor soil quality. One of the things we suggested to this group was to do a collective planting of 0.25 ha of *Acacia angustissima* trees as a reforestation and soil improvement experiment (Figure 10). The trees start as a single stem but eventually develop into multi-stemmed clumps with deep roots. The farmer group members were willing to plant them, so we provided the seedlings and planting instructions.

The trees did so well that they shaded out the sword grass and impressed the farmer group members enough that each of them then planted a plot of their own. The practice spread when other people in the village saw the resulting maize production. Women benefitted because they no longer had to

search for firewood. Now, most people in the village plant this tree in rotation with food crops. The process involves:

7 The first fields in an area have to be planted from a nursery, but afterwards you can pull up volunteer seedlings and transplant those to adjacent fields.

1. Planting *A. angustissima* seedlings from a nursery<sup>7</sup> into a field at 3 m x 3 m spacing. In Botolofio, farmers plant the trees into a cowpea and cassava field, but you can try alternative first-year crops.
2. Harvesting cowpea when mature and cassava after one year
3. Allowing the trees to grow for three years (two years after harvesting cassava), shading out sword grass
4. Preparing for maize planting by cutting the trees for fuelwood, leaving the stumps in place for future regrowth (Figure 11)
5. Lightly burning the field and sowing maize
6. Allowing stems to develop from the *A. angustissima* stumps and selectively pruning regrowth while maize is growing (otherwise the trees' regrowth will compete with the maize)
7. Repeating steps two to seven on rotational patches of land to ensure production of all staple crops on an annual basis

That all began 35 years ago. Today the people at Botolofio say they live because of *Acacia angustissima* trees. They get all the firewood they need from their trees and most of the building poles they want (Figure 11). My own trials in the area, show that one can only expect 350 kg of corn per hectare in a season, even when the land is not cropped each year. The people at Botolofio produce 1.5-3 t/ha (metric tonnes per hectare) now, where the *A. angustissima* trees have been growing. My own trials in the area show that the increase can be estimated to be over three times to about nine times what they used to get. The change is enormous.

This past year (2020), I paid the village of Botolofio a couple of visits and saw additional advantages the trees bring to the farming system. Trees



**Figure 11.** Fuelwood from *Acacia angustissima* trees (A and B) cut before planting maize among remaining stumps (C). Source: Paul Noren.

shade out the grass until the grass is gone and just leaf mulch remains, significantly reducing weeding requirements. Women in the village benefit from this as they perform the bulk of weeding management. Secondly, some maize planted early, matured and was harvested earlier than in other villages, even after a drier than usual dry season. I was amazed at the maize and the apparent lack of effect of a short drought on its performance (Figure 12). The trees were conserving moisture better than the grassland vegetation. During a crucial growth stage for the corn, the root systems of the trees seemed to help with moisture availability even though little remained of the above-ground portion of the trees. My guide, Mr. Ngovene, one of the original planters, pointed out how much better even the wild grass looked near an isolated *A. angustissima* tree. Surrounding stands of *A. angustissima* trees also act as windbreaks, which seemed to keep humidity higher.

The people of Botolofio are still planting new fields of *A. angustissima* trees today, and there are plenty of seedlings to be found. They have a system of trimming and bare rooting the seedlings that are then immediately planted within the surrounding 500 m. The success rate is quite high, and the trees completely shade out the ground within a year.

So far, this system has not spread to other villages very much. It appears that transplanting the bare rooted seedlings only works for neighboring fields, thus making it very unlikely that someone even 10 km away would succeed if they tried. To move the system from one village to another, more than 3 km from each other, takes a lot of preparation. You need to gather seeds during the dry season, plant seeds in a nursery, and then transplant seedlings into planting bags. You would have to set up a nursery, water trees, and purchase planting sacks. These requirements effectively exclude the poor farmer from getting the system started in a new place. Even so, one or two small plots of *A. angustissima* have been planted by local people as far away as 30 km from Botolofio.

This system can be improved upon, but has great merit as a mid-to-long-term solution to food, fuelwood, and building material production. It has proven itself for over 30 years and will continue to expand until a better system replaces it. Hopefully, we can help extend the area in which this system is practiced—[Trial packets of *A. angustissima* seeds are available via [ECHOcommunity.org](http://ECHOcommunity.org)].



**Figure 12.** Healthy maize, during a short drought, growing with previously cut *A. angustissima* trees. Source: Paul Noren

# Books, Websites, and Other Resources: Soy Kit as an Appropriate Technology for Women Entrepreneurs A Review

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Researchers with *Feed the Future Malawi Agriculture Diversification Activity* recently shared an evaluation of a Soy Kit project funded by USAID. This project's objectives were to use soybeans to improve regional nutrition and utilize women's entrepreneurship. In their publication, authors evaluate the economics of the Soy Kit and share an approach to measuring the appropriateness of a technology that author Peter Goldsmith summarizes below.

## An approach to measuring the appropriateness of a technology

While being essential for the introduction of any technology, the metric of appropriateness is multivariate, meaning there are many features in what makes a technology appropriate. In this paper, we use a framework involving 49 indicators of appropriateness. Evaluating this many can be overwhelming, but here I will focus on some fundamental indicators evaluated:

- **Autonomy:** Could entrepreneurs readily operate the technology post-training
- **Raw material availability**
- **Technical accessibility:** Encompassing ease of repairs and service and being an open-source technology
- **Gender appropriateness:** Does the technology match the rhythm, resources, and competencies of women
- **Waste management and multifunctionality:** Allowing entrepreneurs to utilize all the product components, including co-products and by-products (secondary goods generated during manufacturing)

## Summary of the Soy Kit

In sum, the Soy Kit technology is highly appropriate because it matches women's resource constraints, daily rhythms, market understanding, access to raw materials, and competencies. The capital cost is relatively low--80 USD--and all the equipment and raw material are locally available, which is essential for the adoption and diffusion of a technology. Finally, the payback period is quick, so the return on investment is high. This consideration matches market conditions where soy dairy products [alternatives to cow milk] are novel and not the lowest-cost beverage on the market. Women, therefore, do not need to operate the technology continuously to be profitable but instead produce products when a market opportunity arises, such as a celebration, high traffic events, market days, etc.

The full article can be found at:

Kim, C., and Goldsmith, P.D. 2021. The economics of the soy kit as an appropriate household technology for food entrepreneurs. *Food and Nutrition Bulletin* 42(1): 104-115. <https://doi.org/10.1177/0379572120981183>.

If you cannot directly access the journal, you can request a copy from the authors by emailing them at [soybeaninnovationlab@illinois.edu](mailto:soybeaninnovationlab@illinois.edu).

**ECHO East Africa Event**

**Virtual ECHO East Africa Symposium on Sustainable Agriculture  
and Appropriate Technologies**

ONLINE EVENT

September 28-30, 2021

**ECHO Florida Event**

**ECHO's 28th Annual International Agriculture Conference**

ECHO's Global Farm in Florida, USA

November 16-18, 2021

## Upcoming Events

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