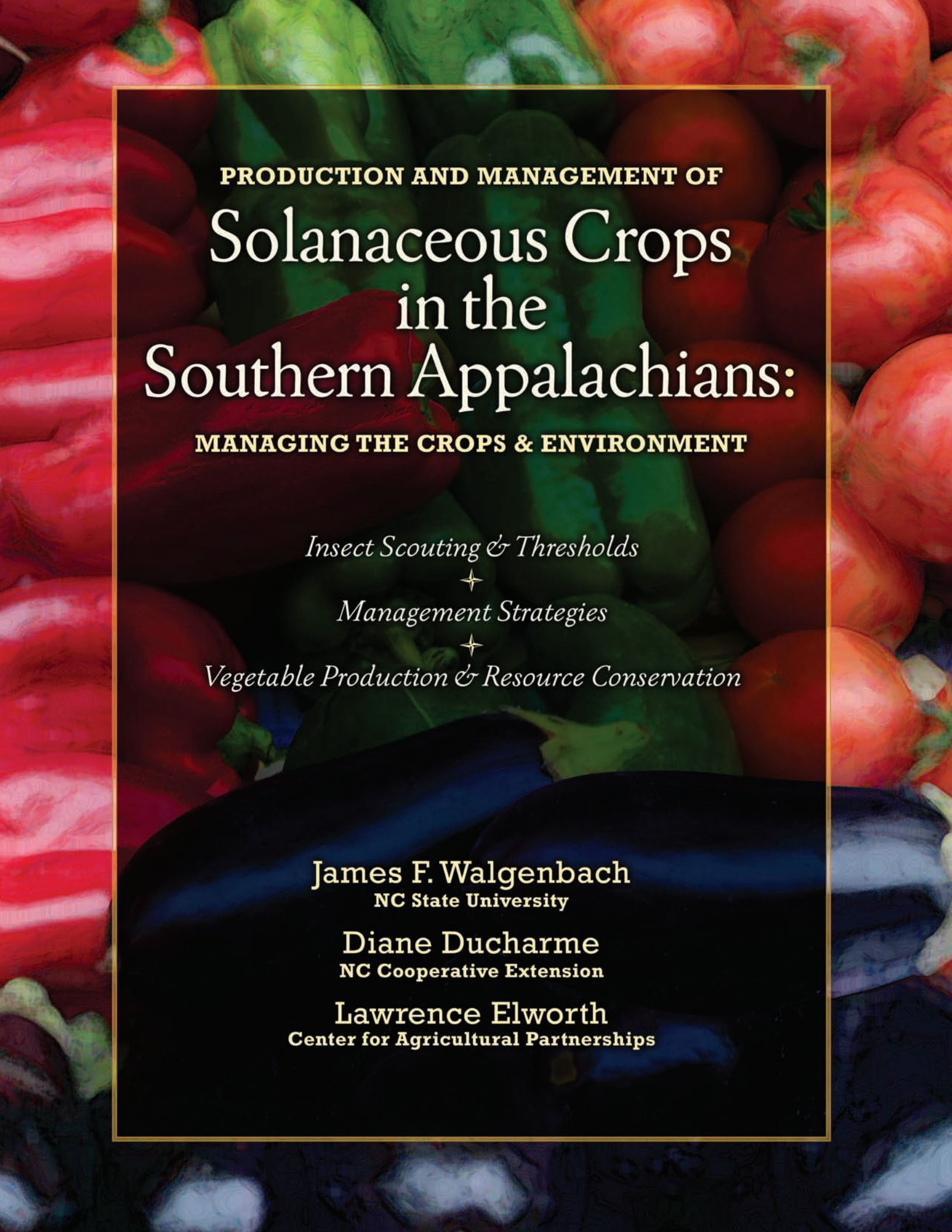

PRODUCTION AND MANAGEMENT OF

Solanaceous Crops in the Southern Appalachians:

MANAGING THE CROPS & ENVIRONMENT

Insect Scouting & Thresholds

✦

Management Strategies

✦

Vegetable Production & Resource Conservation

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INTRODUCTION

What do conservation programs have to do with vegetable growers in North Carolina?

Until recently, vegetable growers in North Carolina have had little experience or reason to be aware of the conservation programs that are included in the Farm Bill. Growers figured that the programs mostly applied to row crop or livestock farmers. But that began to change when the 2002 Farm Bill was passed. Conservation programs received a large increase in funds so that now more than one billion dollars is available for conservation programs—more than USDA's combined research and extension budget.

What that means is that for the first time there have been sufficient dollars, in programs such as the Environmental Quality Incentives Program (EQIP), to include growers who have not received financial assistance: for example, vegetable growers in North Carolina and other states. Just as important, the new Farm Bill being debated now in Congress includes a host of additional provisions that will help vegetable and other specialty crop growers benefit more fully from conservation programs.

Some growers in western North Carolina have already successfully used EQIP to support the adoption of new practices. Of course, as with any effort growers will encounter challenges in using the program as will the people in the county Natural Resources Conservation Service (NRCS) offices who are responsible for working with growers in applying for support. The following information has been compiled to make it easier for vegetable growers to successfully take advantage of the valuable assistance that is available to them.

As the demands on farmers increase, financial and technical assistance is becoming even more critical to growers' ability to farm profitably and stay in business. Conservation programs are a valuable opportunity for North Carolina vegetable growers and an increasingly viable option to support good farming practices in our region.

BENEFITING FROM CONSERVATION PROGRAM OPPORTUNITIES:
A Step-By-Step Guide

Farmers understand better than most people the value of farming practices that conserve natural resources and protect the environment. They also know implementing those practices can be expensive because the initial costs can rarely be recovered from the sale of their crops. To better support growers' efforts, the 2002 Farm Bill increased the funding available to assist growers with the expense of initiating conservation practices. One of the programs funded by the Farm Bill is the Environmental Quality Incentives Program (EQIP). EQIP is a voluntary program administered by the Natural Resources Conservation Service (NRCS) that provides payments to eligible growers for a wide range of practices on their farms.

If you have had little experience with the Farm Bill, NRCS, or government conservation programs, taking advantage of these opportunities may seem challenging. This guide is intended to be a grower-friendly aid that helps you successfully negotiate the steps to applying for EQIP payments. Here are the four basic steps:

STEP ONE

Contact your nearest NRCS office and tell them you want to apply for EQIP.

You can find your local NRCS office in the phone book. To find the NRCS office in your county look in your phone book under United States Government – Agriculture Dept. – Natural Resources Conservation Service or check: http://www.nc.nrcs.usda.gov/about/. Click "Find a Service Center" at the left, to access the directory.

If you have never participated in a USDA program before, first, stop by the USDA Farm Services Agency (FSA) office in the same building as the NRCS office. There you will sign a proof of ownership or lease for the property you are farming and for which you wish to apply. You will need to supply your name, address, social security number, tax ID# if you file taxes under a different number than your SS#, and documentation of who owns the land, such as a deed or tax statement. (If you already have an FSA loan this step is not necessary.)

You should also have a map or aerial photo of your farm. At your NRCS meeting, the conservationist will discuss your plans for your farm and will help you fill out the paperwork. The conservationist will guide you through the process of applying. **While there may seem to be a lot of paperwork involved, most of it is for the NRCS staff to fill out and they are skilled in simplifying the process for growers.** Of course, any information in your application will be kept confidential.

STEP TWO

Work with NRCS to identify site-specific conservation practices that fit your farm.

The District Conservationist or a conservation planner working with the District Conservationist will come to your farm to help you identify practices that are eligible for EQIP or similar programs. The goal is to work together to identify what makes sense for your farm, both for resource conservation and maintaining farm production. They will help you to develop a plan to address all the concerns identified during the visit. This is a free plan for your use in choosing what you want to do and when.

For your meeting you may want to have available some of the following items:

- A farm layout or aerial photo of the farm
- A list of areas where you have conservation concerns
- A list of crops and rotation schedules, if applicable
- Pest and nutrient management records

The District Conservationist will help you identify practices and which resources (such as soil, water, air, etc.) those practices will address. In doing so he or she will also help you determine whether your application is likely to have priority for funding under EQIP. As a general rule, growers who are able to apply multiple practices, that improve more than one resource, have a higher priority for funding.

There are options that have been designed specifically for vegetable growers that are available through EQIP. These have been established to help in minimizing the impacts of methyl bromide use and in helping growers become familiar with the use of alternatives* :

- Use of methyl bromide alternatives
- Use of virtually impermeable film (VIF) tarping
- Use of fall cover crop and methyl bromide alternative

Here are some other practices to consider for your operation (followed by the practice number). You and the district conservationist may find other practices that are applicable to your farm.

- Nutrient management (590)
- Ag chemical containment facility (702)
- Field border (386)
- Critical area treatment (342)
- Windbreak establishment (380)
- Filter strips (393)
- Tree and Shrub establishment (612)
- Wetland restoration (657)
- Residue management (334)
- Heavy use area protection (561)

STEP THREE

Complete the application.

Once you have determined the practices most valuable for your operation, you and the District Conservationist will complete your application. If you are a Limited Resource Producer or Beginning Farmer you are eligible for higher payments (Check with the NRCS staff to determine if you qualify.)

STEP FOUR

Submit the application to NRCS.

Once you have completed and submitted your application to NRCS, it will be ranked with other applications in the state based on the number of points it has received. The NRCS District Conservationist will contact you about whether or not your application is funded. If your application has been accepted, you will complete and sign a contract stating the payments and your obligations.

AFTER YOU HAVE APPLIED

Applications are ranked with other applications in your area based on a system of points. The number of points assigned to each of the practices you want to use on your farm is related to the amount of environmental benefit resulting from these practices. Again, applications that include multiple practices have a higher priority for funding because they offer greater conservation benefits. All applications within a given area are ranked using the same criteria to assure that everyone is treated fairly.

The NRCS District Conservationist will let you know whether or not your application is funded. If your application has been accepted, you will complete and sign a contract specifying the payments and the work you will do on your farm.

County offices in Western North Carolina are:

- Buncombe - 828-254-0916x3
- Haywood - 828-456-5132x3
- Henderson - 828-693-1629x3
- Jackson - 828-586-6344
- Madison - 828-649-3313x3
- Polk - 828-894-8823
- Rowan - 704-637-1604
- Rutherford - 828-287-4220x3
- Swain - 828-488-3785
- Transylvania - 828-884-3230

FAQs ABOUT THE ENVIRONMENTAL QUALITY INCENTIVES PROGRAM.

1) What is EQIP?

EQIP – the Environmental Quality Incentives Program, administered by USDA's Natural Resources Conservation Service (NRCS), provides financial and technical assistance to eligible growers to support the additional cost of using a wide range of environmentally sound farming practices on their farms. Participation is voluntary and initiated by the grower who submits an application for funding.

2) Who can qualify for EQIP? *

- Agricultural producers who make at least $1,000 in gross farm sales.
- Applicant must control the land for the contract period (may own or lease).
- Individuals or entities that have an average adjusted gross income (AGI) of less than $2.5 million for the three tax years immediately preceding the year the contract is approved.
- Growers with an AGI above $2.5 million can qualify if 75 percent of the AGI is derived from farming, ranching, or forestry operation.
- An owner with multiple entities or management units can apply for separate contracts for those units within the same fiscal year.

Eligible land includes cropland, rangeland, pasture, forestland, and other farm or ranch lands where the program is delivered.

**These criteria are likely to change in the 2008 Farm Bill.*

3) How are applications selected?

- Applications are ranked with other applications in your county based on a system of points. The number of points assigned to each of the practices you want to use on your farm is related to the amount of environmental benefit resulting from these practices.
- Applications that include multiple practices have a higher likelihood of being approved for funding because they offer greater conservation benefits.

4) What kinds of financial assistance are available?

- EQIP provides payments as incentives to growers to use practices such as nutrient management, integrated pest management, irrigation water management, and wildlife habitat management.
- Payments through EQIP may be provided for up to three years to encourage producers to carry out management practices they may not otherwise use without the program incentive.
- The rates are set to cover a substantial portion of the costs of certain conservation practices and installations, such as irrigation conversions, and other practices important to improving and maintaining the health of natural resources in the area. Limited-resource or beginning farmers (farming for less than 10 years) may qualify for higher rates on certain practices.

5) How can a grower apply?

Growers may get an application at any USDA service center. After the initial application (one page), NRCS makes an appointment with the grower to establish which practices the grower would like to implement.

6) When should a grower apply?

Growers can apply any time of the year. However, there is a deadline each year by which applications need to be received to be fully considered. NRCS will be able to let growers know when the deadlines are coming up

7) How do you find out if your contract is approved?

The initial round of application ranking is usually complete by mid to late January and will be completed by February 15, 2008. Approved applicants are informed as soon as possible after that date.

8) When can the work begin on the items listed in the contract?

Work can begin once the contract is signed. No work covered by payments in the contract can begin until the contract is signed. There are no retroactive payments for work initiated early.

9) How long do the contracts usually run?

- Contracts based solely on incentive payments are generally 2 – 3 years.
- Contracts that include installations can run 5 – 10 years, but most contracts are 3 – 5 years or less.

If the land is sold or leased to another entity, the contract can "follow" the new operator - they must comply with and complete the contract.

10) When does a grower get payments from NRCS?

Contract participants are paid when a practice is certified complete by the county NRCS office and it meets the intent, purpose and specification of the NRCS practice. Generally, payments will be made within 4-6 weeks of the payment documents being signed and an updated/current/accurate direct deposit is on file. As of 2008, growers can elect to receive up front payments for management practices. Keep in mind that payments are classed as income for tax purposes.

11) Who administers EQIP?

NRCS, the Natural Resources Conservation Service, administers EQIP based on national, state, and local priorities. On the national level, NRCS sets policy and develops program rules and procedures, and identifies national resource priorities. The State NRCS office convenes the State Technical Advisory Committee (STAC). The STAC identifies resource priorities on the state level, eligible practices, payment levels and limits, and provides technical leadership (engineering, plant materials specialists, etc).

12) What effect will the new Farm Bill have on EQIP for the coming year?

In general, it is not likely that the programs will change very much. There is a good chance that more money will be available for EQIP and some added priority for specialty crop production. While there may be some program changes for NRCS the process by which growers participate will remain basically the same.

SUMMARY OF METHYL BROMIDE ALTERNATIVES

1. The first step is to ask the question "What is the pest that I am trying to control?"

2. The second step is determining what alternative(s) are going to work best on that particular pest. We no longer have the one chemical, like Methyl Bromide, that will work on the major pest categories that growers are facing.

3. The methyl bromide alternatives include:
   - Telone / Chloropicrin
   - Metam Sodium
   - Basamid
   - Iodomethane (MIDAS)
   - Chloropicrin

Other chemicals in consideration in the IR-4 program include: Sodium azide, Propylene oxide, fosthiazate, STAN, F3825 200CS, Herbicides (Sandea, Evoke), K-Pam, DMDS, Acrolein. There are some nonchemical options including: Compost-based systems; Solarization; Cabbage residue; and other biological inputs.

Chart 1: Pest Management of the Methyl Bromide Alternatives

PRODUCT	NEMATODES	DISEASE	NUTSEDGE	ANNUAL WEEDS
Telone C-35	★★★★★	★★★★★	★	★★★
Telone C-35 + VIF	★★★★★	★★★★★	★★★	★★★
Metan Sodium (MS)	★★	★★★	?	★★★★
Chloropicrin	★	★★★★★	?	?
Chloropicrin + MS	★★★★★	★★	?	★★★★
RATINGS: ★★★★★ most effective > ★ least effective ? information unavailable at present				

Chart 2: Application Methods for Methyl Bromide Alternatives

PRODUCT	Plant Back	DRIP	SHANK
Telone C-35	21 days	No	Yes
InLine	21 days	Yes	No
Chloropicrin	14-21 days	Yes	Yes
Vapam / K-Pam	14-21 days	Yes	Yes
Midas (iodomethane)	7-14 days	Yes	Yes

FAQs FROM GROWERS ON METHYL BROMIDE ALTERNATIVES AND VIF TARPING

1) What chemical alternatives to methyl bromide are available to vegetable growers in Western North Carolina? What are the formulations? How are they applied?

- **Telone:** There are several formulations the primary of which are Telone as a stand alone product; Telone mixed with 30% chloropicrin (Telone C-35), is available in several different formulations that can all be shank applied; and an EC formulation of Telone C-35 which is applied through the drip system.
- **Metam Sodium** (Vapam, Sectagon) can be applied with shanks, spray, or as a drip application. Dripping this chemical moves it through the soil—shanking or spraying will not adequately treat the soil; it needs to be moved with either water, or physically and the bed needs to be rotivated after application.
- **Chloropicrin** is also available as a stand alone chemical, and is shank applied.
- **MIDAS** is now available and is shank applied— it is available in a 50/50 chloropicrin mix.

2) What is the spacing between the two drip tapes in the beds if using in-line application of methyl bromide alternatives and does this matter?

The distance between the drip tapes is not the critical factor here—the critical part is getting the bed treated properly, and that is done by adequately wetting the entire soil profile. Two tapes are recommended because on most soils, it is impossible to get the "shoulders" of the bed treated if the drip tape is a foot or more away. For crops like strawberries, peppers and others where 2 rows of plants are put into each raised bed—the drip tape can go inside or outside the plant holes based on the best positioning for the grower.

3) What is the typical drip tape gpm (in other words what is the spacing of holes in the drip tape itself) and does this matter for MB alternatives?

Most of the drip tape used in NCSU research has an emitter spacing of 12 inches, and a flow rate of near 0.5 GPM per 100 feet of tape. Again, the point is to adequately treat (wet) the entire bed. Given the wide variety of different soil types, emitter spacings and emitter flow rates there is no complete and definitive set of recommendations. The key is still being able to adequately wet the bed in a reasonable amount of time. Adequately wet means that the entire bed receives moisture from the application, but without causing the beds to collapse from moisture and having water pool at the row ends and row middles.

4) Will the methyl bromide alternatives melt the drip tape?

There has been no evidence of this if using the alternative at the appropriate labeled rates. Although inline chemicals will melt PVC at too high concentrations, there has been no credible report of damage to the actual drip tape.

5) What is the plant back time when using VIF tarping?

The best idea is to allow the full time between application and planting as indicated on labels, even if using reduced rates under VIF.

6) What is the additional requirement of equipment necessary for growers to apply the alternatives through the drip tape?

The injection system currently being used by NCSU researchers is extremely simple. Using the same nitrogen tank and coupling from the current MB rig, you can pressurize your chemical tank. Then a line connects to the chemical tank output, runs through a filter screen, then we have a shut-off valve. The line then continues through a small screen, and an orifice plate, and then continues into the injection point of the irrigation system. That part of the system is going to cost less than $50. This assumes that all the proper back flow systems, and other safety systems are in place in the irrigation system—it is critical to have the back-flow preventatives in place when doing any chemical application. There are also static mixers that can be purchased and used to ensure adequate mixing of the water and chemical, and those will drive up the cost.

7) What are the specific consideration for timing (this includes moisture and temperature regimes necessary) for the specific methyl bromide alternative applications?

There are no hard and fast rules given the range of possible conditions and the number of changes to the labels each year. The alternatives seem to be more sensitive to moisture and temperature because of the vapor pressure issue. Cooler temperatures are going to greatly reduce the gassing—though land cooler than 60 degrees F is not often fumigated, some labels allow cooler temperature applications. Moisture is a big issue —several of the alternatives (especially Telone) love water, and will gravitate to it. If trying to fumigate with a shank application in wet soil, the fumigant may be bound up by soil water. Another consideration is that the two factors interact. Cool and wet is a deadly combination for some of the alternatives, but cool and dry is not as bad—neither is hot and wet (not too wet).

8) What types of VIF tarping seem to be working best?

NCSU researchers have had good results with non-embossed film in a variety of applications over a range of different soil types. Others have reported good results with the embossed products. There seem to be significant differences in the permeability of VIF to different chemicals. USDA is seriously considering a rating system for all VIF options that documents how they work with various chemicals - researchers are testing all the current products. Embossed vs non-embossed? Currently none of the VIF plastic manufacturers have ever claimed that less water is required with VIF tarping.

9) What has been the experience from Florida growers with methyl bromide alternatives?

Here are some highlights from Dr. Joe Noling's (University of Florida) experiences with strawberry production:

- Cost per acre of production will ultimately drive the change to MB alternatives for farmers
- Found that using a combination/integration of alternatives is working well
  - Specifically pre-bed application of Telone C35 (35 gals/A) injected into beds 12" deep
  - Chloropicrin run through drip tape in spring
  - Plus a complementary herbicide
- Using VIF
  - No difference in plant size/yield
  - Dramatic improvements with embossed products
- Things to remember from Florida
  - Florida has different soil types than NC
  - Register pesticides might be different

INSECT MANAGEMENT ON SOLANACEOUS CROPS

Tomato, Pepper, and Eggplant in Western North Carolina

Insects and mites are important pests of Solanaceous crops grown in the Southern Appalachian Mountains, including western North Carolina. Because of high crop value and strict cosmetic standards demanded by consumers, there is an extremely low tolerance for damage. While certain cultural practices and biological control agents can help to suppress certain pest populations, invariably insecticides are required to produce a profitable crop.

Care must be taken to use insecticides in a responsible manner to protect water resources and non-target organisms, and to avoid illegal residues that may impact human health. When using insecticides, it is critical that the label be read before applying chemicals, because many insecticides have restrictions that must be obeyed to avoid endangering the environment, farm workers and consumers of produce. Fortunately, a diversity of new insecticides that pose a reduced-risk to the environment and human health compared to older, broadspectrum insecticides, have been registered on fruit and vegetable crops. A characteristic of these new insecticides, however, is that they have a narrower spectrum of pest activity compared to older chemicals. Hence, when selecting an insecticide to apply, it is imperative that this decision is based on knowledge of the pest(s) present in the field.

Key Arthropod Pests

There is a diversity of insects and mites that can potentially infest tomato, pepper and eggplant in the Southern Appalachian Region. The list of pests and the crops they attack are shown in Table 1. It should be noted that key pests are those that are common and have the potential to damage a crop almost every year if precautions are not taken. A few insects not listed in Table 1 can occasionally infest Solanaceous crops in this region, including leafminers, vegetable weevils, pepper maggot, and eggplant lace bug, but the incidence of these problems is extremely rare.

Table 1: Importance of various insects as pests on Solanaceous crops in Western North Carolina

PEST	IMPORTANCE RATING* EGGPLANT	PEPPER	TOMATO
Aphids			
Green Peach Aphid	★★★	★★★	★★
Potato Aphid	★	★	★★
Thrips	★★★	★★★	★★★
Whiteflies			
Greenhouse Whitefly	★★	★	★★
Silverleaf Whitefly	★★	★	★★
Stink Bugs	★★	★★	★★★
Flea Beetles	★★	★★	★★
Pepper Weevil		★	
Colorado Potato Beetle	★	★	★
Mites			
Twospotted Spider Mite	★★★	★	★★★
Broad Mite	★	★★	★
Fruitworms	★★★	★★★	★★★
Armyworms	★★	★★	★★
European Corn Borer	★	★★★	—
Tomato Pinworm	—	—	★
Loopers and Hornworms	★★	★★	★★

*RATINGS: ★★★ Key Pest ★★ Occasional Pest ★ Rare Pest — Non Pest

Aphids *(Pictures 1 & 2)*

The most common aphids infesting Solanaceous crops are the green peach aphid and potato aphid. The green peach aphid is more difficult to control, because populations have demonstrated the potential to develop resistance to insecticides very quickly. Resistance often occurs when one type of insecticide is relied upon extensively for insect control. For this reason it is wise to rotate insecticides with different modes of action during the season. Winged aphids (referred to as alates) infest fields in the spring or summer when they disperse from weed hosts. During the summer months, wingless aphids (referred to as apterous) will reproduce within the crop. Insecticides should

be applied specifically for aphids when 25% of plants are infested. Aphids produce honeydew which serves as a substrate for sooty mold growth, which can blacken leaves and fruit.

The green peach aphid and certain other aphid species are also vectors of viruses that can infest Solanaceous crops, including cucumber mosaic virus (CMV) that recently has been detected with increasing frequency in peppers in western North Carolina. Winged aphids acquire CMV from weed hosts before entering a field, and they can infest a plant after feeding for only a few seconds. Because of this rapid transmission, insecticides will not prevent primary spread of CMV. Where this or other mosaic viruses are a problem, the use of reflective mulches and/or frequent, high pressure applications of stylet oil are necessary to minimize the spread of virus.

Thrips *(Pictures 3-5)*

At least three different species of thrips are potential pests of Solanaceous fruiting vegetable crops in western North Carolina; tobacco thrips, western flower thrips and flower thrips. The tobacco thrips and western flower thrips are both efficient vectors of tomato spotted wilt virus. The tobacco thrips is primarily a foliar feeder and is most abundant from late April to early June. The western flower thrips will feed on both foliage and in flowers, while the flower thrips is primarily a flower feeder. Western flower thrips and flower thrips are more abundant during the late spring and summer months. In western North Carolina, spread of TSWV from weeds to crops by thrips occurs from late May through June. In areas where TSWV is a concern, treatment of transplants with imidacloprid before setting in the field (see below) will help to suppress, but not eliminate, primary spread of virus from weeds to crops. Secondary spread of virus (i.e., from plant to plant within the field) requires that thrips complete their life cycle on the crop within the field. This is because only the first instar thrips (first stage after hatching from eggs) can acquire the virus, but only adults can transmit the virus. Because it requires 10 to 14 days for thrips to complete development under summer temperatures in the Southern Appalachians, an insecticide effective against thrips applied at about two week intervals will minimize potential for secondary transmission of TSWV. Secondary spread occurs during June and July primarily by the western flower thrips.

Thrips feeding and egg laying into small fruitlets before stamens have shed can result in scarred and pot-marked fruit. This type of damage has been most commonly associated with western flower thrips. A threshold level of 5 thrips per flower cluster is recommended to dictate the need for insecticide sprays to control thrips in flowers. While most neonicotinoid insecticides applied to transplants or through drip irrigation are effective in controlling thrips feeding on flowers, they will not control thrips in flowers.

Whiteflies *(Pictures 6-9)*

Two species of whiteflies have been observed on tomatoes and eggplant in western North Carolina; the greenhouse whitefly and the silverleaf whitefly. Neither species is known to overwinter outdoors in North Carolina. Sources of field infestations include adults that disperse from greenhouses (where they can overwinter) and infested transplants that are shipped from more southern areas. Whiteflies have high reproductive rates and can increase to high densities very quickly. Whitefly feeding can result in a condition known as irregular ripening of tomatoes, and honeydew excreted on leaves and fruit serves as a substrate for the growth of sooty mold. In addition, whiteflies can also transmit a complex of geminiviruses. To date, the incidence of whitefly-transmitted geminiviruses has been very low in North Carolina. A provisional action threshold of 5 nymphs per 10 leaflets is recommended to dictate the need for insecticidal control of whiteflies.

Stink Bugs *(Pictures 10-13)*

The southern green stink bug and brown stink bug are relatively common insect pests that feed on and damage fruit. Damage occurs when stink bugs insert their sucking mouthparts into fruit and inject a toxic salivary secretion before removing cellular contents. Feeding damage results in a discolored area of the fruit. Stink bugs enter tomato fields from non-treated areas surrounding the field. While adults are the primary cause of damage, if left unchecked they can reproduce in the field and nymphs can also feed on and damage fruit.

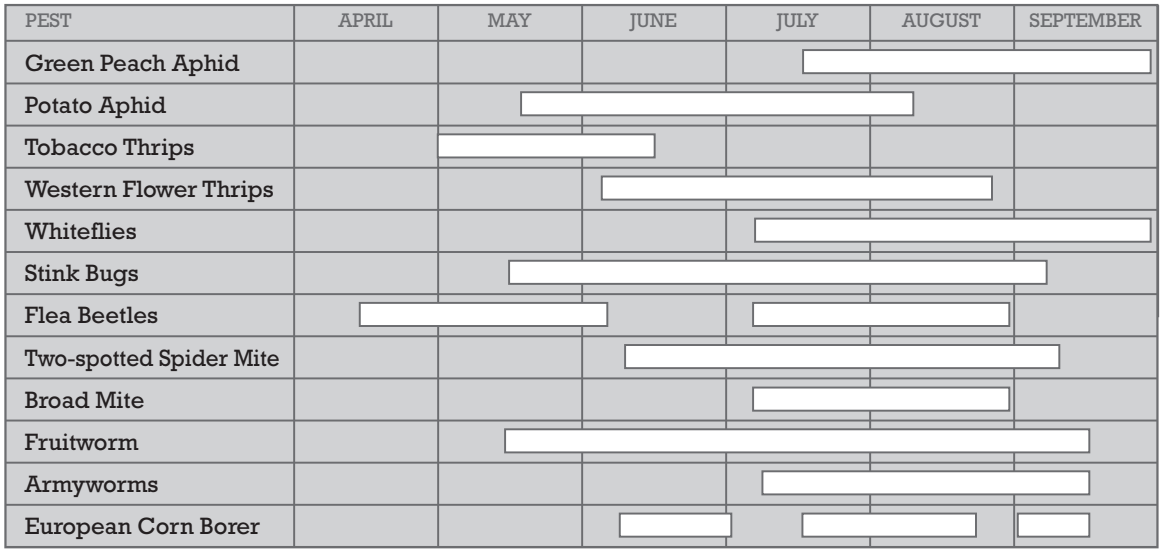
Flea Beetles and Colorado Potato Beetle *(Pictures 14-17)*

Flea beetles are small beetles that feed on the foliage of plants and are common early season pests, while Colorado potato beetle is an uncommon pest of commercially grown Solanaceous crops in western North Carolina. The tobacco flea beetle, potato flea beetle and eggplant flea beetle are all common in North Carolina. Most flea beetles overwinter in the adult stage and infest newly planted crops in the spring, causing small round shotholes in the foliage. Colorado potato beetle also overwinters as adults, and in the spring they infest Solanaceous crops and lay eggs on the underside of leaves. Large larvae are voracious feeders and can rapidly defoliate plants.

Mites *(Pictures 18-20)*

Three mite species are important on Solanaceous crops in western North Carolina; the two-spotted spider mite, the carmine mite and the broad mite. The two-spotted spider mite is most common on tomatoes and eggplant, but rarely do they develop to damaging levels on pepper. Two-spotted spider mites are generally most problematic in fields that are not rotated out of tomatoes for one or two years, and where pyrethroid insecticides are applied. However, mites can develop to high densities even with the use of rotation and non-pyrethroid insecticides. The carmine mite is not common, but may appear later in the season. Broad mites feed in the apical meristem of plants, are very small, and can only be observed with the aid of a microscope. They are most common on peppers and eggplant. On infested plants, new leaves are deformed and fruit has a brownish scarring on the surface.

Fig. 1: Periods of greatest potential for damage to Solanaceous crops by key arthropod pests in the Southern Appalachians



Fruitworms *(Pictures 21-24)*

Two species of fruitworms are the most common and potentially damaging pests of tomatoes in western North Carolina. The tomato fruitworm (also called the corn earworm) is most common, but in certain years the closely related tobacco budworm is also important. Moths of both species lay eggs singly on tomato leaves or flowers. Larvae will hatch from eggs within a few days, after which they initially feed on foliage for a short time before boring into fruit. Hence, using a 7-day interval spray schedule during periods when moths are active is important to minimize damage. Fruitworm are a potential problem from late May to September, although activity is most intense in July and August. Fresh silking corn is a preferred egg laying host of tomato fruitworm, but when corn silk dries moths then switch egg laying to nearby vegetables crops. Historically, the tobacco budworm is slightly more tolerant to insecticides than tomato fruitworm.

Armyworms *(Pictures 25-28)*

Three species of armyworms are potential pests, including the beet armyworm, southern armyworm and yellow-striped armyworm. All species lay eggs in masses, so individual plants may contain many larvae. In contrast to fruitworms, armyworms will feed extensively on foliage as well as fruit. Among these three species, the beet armyworm is most damaging because of its tolerance to many insecticides, but it is sporadic in occurrence. Infestations do not occur every year, and even in years when populations are high, infestations are often geographically clumped so that not every field is infested.

European Corn Borer *(Pictures 29)*

The European corn borer is an occasional late-season pest of pepper, although in some years it can become a serious pest. There are three generations per season, with periods of moth activity occurring during June, late July to early August, and September. Corn is a preferred host of corn borers up to the time plants begin to mature and dry, after which moths switch their oviposition to other crops, including pepper. Hence, peppers are most susceptible to attack during August and September. This insect overwinters as mature larvae in old corn stalks or corn cobs, and when temperatures increase above 50°F they complete development to the pupal stage and adult moths emerge in June. Some field corn planted in western NC is genetically modified to confer resistance to European corn borer, and this has presumably contributed to reduced population densities of this pest. On pepper, moths lay eggs in masses on leaves, and hatching larvae then disperse and seek out fruit to borer into. Larvae enter fruit near the cap of the fruit (where the stem attaches), and infested fruit may not show external signs of damage until frass has accumulated near the entrance point. There are two different corn borer biotypes in North Carolina based on the composition of the pheromone emitted by females. If using pheromone traps to monitor corn borer, pheromone lures sold as the Iowa strain should be used in western NC.

Loopers, Hornworms and Pinworm

Larvae of these insects can cause damage to eggplant, pepper and tomato, but they are fairly uncommon in commercially managed fields. Hornworms and loopers are primarily feeders of foliage, and infestations are easily observed. On rare occasions, late-season tomato pinworm populations can migrate from more southern states and cause damage. Pinworm moths deposit eggs on leaves, and the first two larval instars mine in leaves. Subsequent instar larvae bore into fruit, usually under the calyx.

Scouting and Management Thresholds

The use of threshold levels to dictate the need for insecticide applications requires careful scouting on at least a weekly basis. Unfortunately, precise scouting procedures and threshold levels have not been developed or verified for many pests. In addition, for certain insect or mite pests, the large sample size and time or cost required to obtain a precise estimate of pest density makes it difficult to use a scouting program. However, relatively simple sampling procedures and threshold levels are available for certain pests, and their use can help to avoid unnecessary pesticide applications. Sampling and thresholds are most important for those insects that have the greatest potential for developing resistance – mites, aphids, thrips, and whiteflies. Shown in Table 2 are recommended sampling procedures and thresholds for some important pests in the Southern Appalachians.

Application and Selection of Insecticides

Insect control may be necessary anytime from the production of transplants in the greenhouse to just before the last harvest in the field. The most common pests during greenhouse transplant production are thrips and whiteflies. Regardless of where the plant is grown (greenhouse or field), the crop must be listed on the label of the insecticide applied. In addition, insecticide labels also specify the manner in which they may be applied. For instance, if the label does indicate that it can be in transplant water or through drip or trickle irrigation systems, they cannot be applied in this manner. To avoid violating the law, it is critical that applicators read the label and follow precautions before applying all insecticides.

Table 2: Scouting procedures and treatment threshold levels for some key arthropod pests of fruiting Solanaceous crops. **Note that thresholds have not been established for certain pests.*

PEST	SCOUTING METHOD	THRESHOLD
Green Peach Aphid	Inspect 1 mid-plant leaf on 10 consecutive plants in 5 locations per field.	Average of 3 aphids per leaf.
Potato Aphid	Inspect 10 upper leaves on 10 consecutive plants in 5 locations per field. Record the number of leaves infested with wingless aphids.	25% of plants infested.
Thrips	Hold a white index card under a group of flowers and tap the peduncle. Record the number of thrips dislodged.	Average of 1 thrips per flower, or 5 per flower cluster.
Two-spotted Spider Mite	Observe the terminal leaflet on 10 upper plant leaves on 10 consecutive plants in 5 locations per field.	Average of 2 mites per leaflet.
Whiteflies	For adults, observe the most recently expanded leaf on 20 plants per field. For immatures (nymphs or pupae), observe a mid-plant leaflet on 20 plants per field.	Adults – average of 10 adults per leaf. Immatures – average of 1 immature per leaflet.
Fruitworm	Inspect the upper 3 leaves and flowers on 10 consecutive plants in 10 locations per field. Record the number of fruitworm eggs.	Presence of any eggs.

In recent years there has been a diversity of new insecticides registered by the EPA that are classified as "reduced-risk" insecticides. Insecticides granted reduced-risk status by the EPA have the following characteristics compared to older insecticide chemistry: 1) reduces pesticide risks to human health; (2) reduces pesticide risks to non-target organisms; (3) reduces the potential for contamination of valued, environmental resources, and/or (4) broadens adoption of IPM or makes it more effective. Examples of such insecticides used in vegetable production are Assail, Avaunt, Fulfill, Intrepid, SpinTor and Radiant.

Insecticide Resistance Management

Insecticide resistance management refers to pest management practices that will delay or prevent the development of resistance development in an insect population. Not all insect pests are prone to developing resistance; generally those with a rapid reproductive rate and a narrow host range are most likely to develop resistance. Among those arthropod pests attacking eggplant, pepper and tomato, the green peach aphid, western flower thrips, greenhouse and silverleaf whitefly, and two-spotted spider have a history of resistance problems.
The following resistance management practices are useful for these pests.

1. Do not apply an insecticide or miticide when populations are below damaging levels.
2. If multiple applications are necessary to control these pests, rotate insecticides with different modes of action against different generations.

The Insecticide Resistance Action Committee (IRAC) has developed a classification system of insecticides and miticides with different modes of action. Table 4 lists the relative efficacy of insecticides and miticides against key pests of Solanaceous crops in western North Carolina. Insecticides are grouped by the IRAC mode of action classification, of which there are 28 different groupings. Do not over apply pesticides grouped with the same mode of action.

Transplant Treatment before Planting

The neonicotinoid insecticide imidacloprid is registered for use on greenhouse transplants before setting in the field. This application should be made no more than 7 days before setting in the field, and will protect plants against aphids, flea beetles, thrips, and whiteflies for about two weeks after planting. This approach is particularly important in areas where tomato spotted wilt virus is a concern. This application should target the soil media so that imidacloprid is taken up by the roots. Transplants in cell flats can be treated in one of the following two manners:

1. Uniform high volume spray to the foliage, followed immediately by sufficient overhead irrigation to wash material off leaves into the soil, but not so much water that material drains from the bottom of cell flats.
2. Injection to overhead irrigation system using sufficient water to thoroughly saturate soil media, but so much as to allow loss of material by gravitation from the bottom of cell flats.

Table 3: Imidacloprid products registered for planthouse application tomato, eggplant, and pepper.

PRODUCT	RATE/10,000 PLANTS
Admire Pro 4.6F	0.44 fluid ounces
Admire 2F	1 fluid ounce
Widow 2F	1 fluid ounce

Drip Irrigation Application

A number of different neonicotinoid insecticides are registered for post-transplant use through the drip irrigation system, or to the soil if not using drip irrigation. The advantages of this type of application compared to foliar applications are that these systemic insecticides are more efficiently transported throughout the plant and thus generally more effective against target pests, provide longer residual activity, and are less harmful to non-target organisms. The residual activity will vary depending on plant size, rate of insecticide applied, and soil type, but activity for a minimum of four to six weeks is common. Because of concerns about resistance development, foliar applications of neonicotinoids should not be made if applying materials through drip irrigation systems. To protect water resources, it is critical that label instructions are closely followed, including the use of safety check valves.

The easiest manner to apply neonicotinoids to fruiting Solanaceous vegetables planted as transplants is through the drip irrigation system, or drip irrigation is not used then as a post transplant or hill drench with sufficient water to ensure incorporation to the root zone. Materials registered for this application, along with their relative efficacy against target pests, is shown in Table 4

Foliar Insecticide Applications

Foliar insecticide applications are almost always necessary to protect eggplant, pepper and tomato from damage by direct insect pests. If transplants were treated with imidacloprid before planting, insecticide sprays are generally not needed until the first fruit have developed on plants. However, once tomato fruitworm flight has begun, insecticide applications should be initiated and reapplied at a minimum of 7-day intervals. The appropriate application interval will vary depending on plant growth stage and the residual activity of the insecticide applied. Generally, insecticide application intervals should not exceed 7 days during periods of rapid plant growth. Later in the season when plant growth rate is slower and pest pressure has declined, application intervals may be increased to 10 days.

Table 4: Application rates and relative efficacy of neonicotinoid insecticides applied through drip irrigation or to the soil.

INSECTICIDE	RATE PER ACRE[1]	TOTAL PER ACRE PER YEAR	PRE-HARVEST INTERVAL (d)	RELATIVE EFFICACY (★★★ most effective, ★least effective)				
				APHIDS	TOBACCO THRIPS	WESTERN FLOWER THRIPS[2]	WHITEFLY	FLEA BEETLE
Imadacloprid				★★★	★★★	★	★★★	★★★
Admire Pro 4.6F	7-10.5 fl. oz.	10.5[1]	21					
Admire 2F	16-24 fl. oz.	24.0	21					
Widow 2F	16-24 fl. oz.	24.0	21					
Dinotefuran				★	★★★	★	★★	★★★
Venom 70SG	5-6 oz.	5-6 oz.	21					
Thiamethoxam				★★★	—[3]	—[3]	★★	★★★
Platinum 2SC	5-8 fl. oz.	5-8 fl. oz.	30					

[1] On pepper, the maximum rate per application for Admire Pro is 14 fl oz., and for Admire and Widow 32 fl oz.
[2] Soil or drip applications will control thrips on foliage, but not in flowers.
[3] Not labeled for thrips.

Picture 1: Green Peach Aphid

Picture 2: Potato Aphid

Picture 3: Thrips

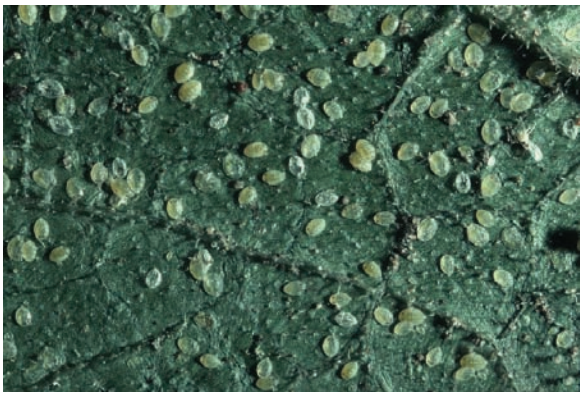
Picture 4: Tomato-Spotted Wilt Virus On Tomato

Picture 5: Thrips Damage On Tomato

Picture 6: Whitefly Adults

Picture 7: Whitefly Adult and Nymphs

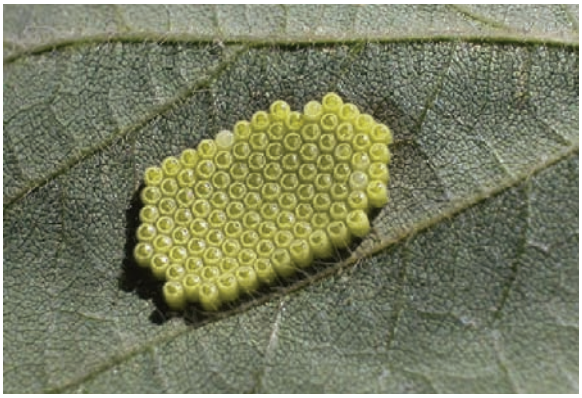
Picture 8 : Greenhouse Whitefly Adult and Nymphs



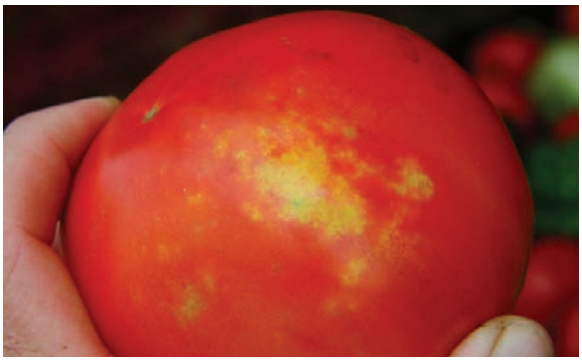
Picture 9: Whitefly Nymphs
Citation: Alton N. Sparks, Jr., University of Georgia, www.insectimages.org

Picture 10: Southern Green Stink Bug Adult
Citation: Alton N. Sparks, Jr., University of Georgia, www.insectimages.org

Picture 11: Brown Stink Bug Adult
Citation: Russ Ottens, University of Georgia, www.insectimages.org



Picture 12: Stink Bug Egg Mass (from UT)



Picture 13: Stink bug damage on tomato

Picture 14: Flea beetle damage

Picture 15 : Colorado Potato Beetle Adult

Picture 16: Colorado Potato Beetle nymph

Picture 17 : Colorado Potato Beetle Egg Mass
Citation: David Cappaert, Michigan State University, www.insectimages.org

Picture 18: Broad Mite Damage on Pepper

Picture 19: Two-spotted spider mite adult

Picture 20: Two-spotted spider mite damage on tomato

Picture 21 : Tomato fruitworm on tomato

Picture 22: Tomato Fruitworm adult

Picture 23: Tomato Fruitworm damage

Picture 24: Tomato fruitworm larva and damage

Picture 25:Beet armyworm on tomato

Picture 26 : Beet armyworm adult
Citation: Paul Harris, www.insectimages.org

Picture 27:Beet armyworm egg mass hatching
Citation: Alton N. Sparks, Jr., University of Georgia, www.insectimages.org

Picture 28: Southern armyworm larva
Citation: Central Science Laboratory, Harpenden Archive, British Crown, www.insectimages.org

Picture 29: Eastern Corn Borer

Table 5: Relative effectiveness ratings of foliar applied insecticides against arthropods affecting Solanaceous fruit vegetables
(3=excellent 2=good 1=poor —=no data or not on label • [1]Crop on which pesticide is registered for use: **E**ggplant **P**epper **T**omato)

MOA CLASS	PESTICIDE (active ingredient)	CROP REGIST.[1]	GPA	WFT	TT	WF	SB	FB	CPB	PW	TSM	BM	TFW	AW	ECB	TPW	LP HW
1	Diazinon (diazinon)	T	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1	Dimethoate (dimethoate)	P T	3	2	3	—	—	—	—	—	—	—	—	—	—	—	—
1	Lannate (methomyl)	E P T	3	2	3	—	—	—	—	—	—	—	3	2	2	3	3
1	Monitor (methamidophos)	T	3	3	3	2	3	3	—	—	—	—	3	1	—	3	3
1	Orthene (acephate)	P	3	1	3	—	—	—	—	—	—	—	2	1	3	—	3
1	Sevin (carbaryl)	E P T	—	1	1	—	1	3	1	—	—	—	2	1	1	1	3
1	Vydate (oxamyl)	E P T	3	2	2	1	—	—	2	3	2	1	1	1	1	1	2
2	Thionex (endosulfan)	E P T	3	1	1	2	3	3	3	—	1	1	3	1	2	2	3
3	Ambush (permethrin)	E P T	1	1	2	1	1	3	2	2	—	—	3	1	3	3	3
3	Asana (esfenvalerate)	E P T	1	1	1	1	1	3	2	2	—	—	3	1	3	3	3
3	Baythroid (cyfluthrin)	E P T	1	1	1	1	2	3	2	3	—	—	3	1	3	3	3
3	Capture (bifenthrin)	E P T	1	1	2	1	3	3	2	3	2	1	3	1	3	3	3
3	Danitol (fenpropathrin)	T	1	1	2	1	3	3	2	—	2	1	3	1	—	3	3
3	Mustang Max (zeta cypermethrin)	E P T	1	1	2	1	3	3	2	3	—	—	3	1	3	3	3
3	Proaxis (gamma cyhalothrin)	E P T	1	1	2	1	3	3	2	2	1	—	3	1	3	3	3
3	Warrior (lambda cyhalothrin)	E P T	1	1	2	1	3	3	2	2	—	—	3	—	3	3	3
4	Actara (thiamethoxam)	P	3	1	3	3	2	3	2	—	—	—	—	—	—	—	—
4	Assail (acetamiprid)	E P T	3	—	3	3	2	2	3	—	—	—	—	—	—	—	—
4	Provado (imidacloprid)	E P T	3	—	3	3	—	2	3	—	—	—	—	—	—	—	—
4	Venom (dinotefuran)	E P T	1	—	3	3	2	3	3	—	—	—	—	—	—	—	—
5	SpinTor (spinosad)	E P T	—	2	2	1	—	—	3	—	1	—	3	3	2	3	3
5	Radiant (spinetoram)	E P T	—	3	3	1	—	1	3	3	1	—	3	3	3	3	3
6	Agri-Mek (abamectin)	E P T	—	1	1	1	—	—	3	—	3	3	—	—	—	3	—
6	Proclaim (emamectin benzoate)	E P T	—	—	—	—	—	—	—	—	—	—	3	3	3	3	3
7	Knack (pyriproxyfen)	E P T	—	—	—	3	—	—	—	—	—	—	—	—	—	—	—
9	Fulfill (pymetrozine)	E P T	3	—	—	2	—	—	—	—	—	—	—	—	—	—	—
11	Dipel (Bacillus thuringiensis)	E P T	—	—	—	—	—	—	—	—	—	—	2	2	—	2	3
16	Courier (buprofezin)	T	—	—	—	3	—	—	—	—	—	—	—	—	—	—	—
18	Intrepid (methoxyfenozide)	E P T	—	—	—	—	—	—	—	—	—	—	3	3	3	2	3
22	Avaunt (indoxacarb)	E P T	—	—	—	—	—	—	3	—	—	—	3	3	3	2	3
23	Oberon (spiromesifen)	E P T	2	—	3	3	—	—	—	—	2	3	—	—	—	—	—
25	Acramite (bifenazate)	E P T	—	—	—	—	—	—	—	—	3	—	—	—	—	—	—
UN	Kelthane (dicofol)	P T	—	—	—	—	—	—	—	—	2	2	—	3	—	—	—

KEY: GPA (green peach aphid) WFT (western flower thrips) TT (tobacco thrips) WF (whitefly) SB (stink bug) FB (flea beetle) CPB (Colorado potato beetle) PW (pepper weevil) TSM (twospotted spider mite) BM (Broad mite) TFW(tomato fruitworm) AW(army worms) ECB (European corn borer) TPW (tomato pinworm) LP/HW (loopers and hornworms)

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