

COTTON INSECT MANAGEMENT

Jeremy K. Greene, Research/Extension Entomologist

Insect pests are major limiting factors in producing cotton in South Carolina. Hundreds of species of insects may be found in cotton, but only a limited number of those species are economically important. A cotton scout must be able to identify the damaging species of insects as well as the common beneficial arthropods. A good scouting program is still the first line of defense against insect pests in cotton. There are many valid techniques that can be used to assess the impact of insects in a field of cotton. The following information is intended to serve as a guide for use in monitoring and controlling infestations of pestiferous insects in cotton. Insecticide treatments should only be applied when numbers of insect pests reach levels that correspond to the economic thresholds described here. Avoid treating infestations that are below thresholds because unnecessary disruptions to populations of beneficial species often result in plant injury by other insect pests.

Since 1996, cotton growers in South Carolina have planted cotton varieties protected from tobacco budworm and bollworm by genes derived from the bacterium, *Bacillus thuringiensis* (Bt). Genes transferred from Bt to cotton enable plants to produce proteins toxic to caterpillars. Cells of leaves, stems, squares, blooms and bolls of these genetically engineered cotton plants contain lethal doses of the toxin. When caterpillars eat the Cry-proteins, their digestive enzymes activate the toxic form of the protein. The Cry-proteins bind to receptors on the lining of the insect gut, and cells are ruptured. The poisoned insects stop feeding within a few hours and die within 2 or 3 days if the dose is sufficiently high. Varieties with single-gene (first-generation) Bt technology provided excellent control (virtually 100%) of tobacco budworm and fair-to-good (about 60 to 90%) control of bollworm over the years (1996-2010). In South Carolina, there was insufficient control of bollworm with single-gene Bt cotton alone, and supplemental applications of insecticides were needed to prevent economic damage.

Thresholds for bollworm in first-generation Bt cotton were developed in response to observations that many problems with bollworm occurred in fields of Bt cotton where there had been moderate to high levels of eggs. For this reason, thresholds were adopted that called for insecticide treatments when egg and small worm numbers were excessive, especially if scouts would be unable to get back within a few days to assess infestations of larvae. An egg threshold of 75 eggs per 100 plants was instituted in the 1997 crop year, along with a threshold of 30 small worms per 100 plants. Square damage has been a poorer indicator of economic damage in Bt cotton, as most surviving larvae have been found in association with bolls and attached dried blooms (commonly called "bloom tags"). Researchers have shown that Bt toxins are apparently expressed in lower concentrations in blooms, pollen, and dried bloom tags, creating a window of opportunity for small bollworms. If small larvae can survive and grow for several days, they are not likely to be killed by Bt toxins.

During the last several years, almost 100% of the cotton acreage in South Carolina was planted to varieties containing two Bt genes for production of dual Cry-proteins. Research has shown that, when additional genes are added that produce supplementary toxic proteins, effectiveness against lepidopteran pests such as bollworms, armyworms, and soybean loopers increases. Availability of Bt technologies changed on 30 September 2009 when the last opportunity to purchase first-generation Bt cotton (Bollgard varieties – for example DP555BR) for planting during the 2010 season expired (i.e. the phasing out of single-gene Bt varieties). Beginning with the 2011 season, only dual-Bt-gene cotton varieties were commercially available. Varieties expressing more than two Bt proteins are now available and continue to be approved and tested.

Cotton with Bt technology has many potential benefits in terms of insect control, but there will continue to be potential problems with stink bugs and other arthropod pests that are not controlled by Bt toxins and that benefit from reduced use of insecticides. Although Bt cotton has offered good-to-excellent control of important caterpillar pests, the best way to maximize benefits of planting transgenic Bt cotton is to scout vigilantly for pests, allowing properly timed sprays when necessary and detecting additional potential shifts in species importance. Researchers with Clemson University will continue to evaluate insect pest thresholds and control methods with new transgenic varieties, and adjustments will be made to recommendations as deemed appropriate.

INSECT PESTS

Thrips feed on leaves and terminals of seedling plants, thereby stunting growth and delaying maturity. Damaged leaves appear crinkled on top, and lower surfaces will often have a silvery sheen. Leaf margins become cupped and terminal buds may be destroyed. Tobacco thrips, *Frankliniella fusca*, is the predominant species encountered in cotton in South Carolina.

Aphids typically infest plant terminals and uppermost leaves initially. These soft-bodied insects have piercing-sucking mouthparts that are used to suck plant juices from leaves and stems. Heavy infestations on the undersides of leaves produce wilting and cause the leaf margins to curl toward the ground. A parasitic wasp and a fungus, *Neozygites fresenii*, often provide adequate aphid control. **Whiteflies** can also damage cotton by sucking plant fluids, but this happens very rarely in South Carolina. These insects are generally controlled by naturally occurring beneficial arthropods before their damage can reduce yields. Both aphids and whiteflies excrete a substance with a high sugar content referred to as honeydew. Heavy infestations of aphids can produce large amounts of honeydew, thereby coating lower leaves, and giving them a shiny appearance. After mature bolls have opened, honeydew may produce sticky lint. Honeydew may also serve as a substrate for the growth of a sooty mold, which stains lint and reduces color grade.

Plant bugs (tarnished plant bug and cotton fleahopper) infrequently cause problems in June and July. Tarnished plant bugs may also puncture small bolls, inflicting damage symptoms similar to that caused by stink bugs. Adults of both species of plant bugs move to cotton from wild host plants. *Lygus* bugs develop in wild hosts such as aster, blue vervain, and fleabane, while fleahoppers are fond of tropic croton and primrose. Both adults and nymphs feed on small squares and other tender plant parts.

Tobacco budworm populations have been increasing during recent years. Historically, most problems with tobacco budworms have occurred in the Coastal Plain from moths that deposited eggs during June (pre-bloom). However, in recent years, populations of tobacco budworm have been detected in early July. Tobacco budworm and bollworm are often called the bollworm/budworm complex because they will often be present in the same field, they eat the same plant structures, and they are morphologically quite similar as larvae. Before first bloom, in non-Bt cotton, fields should be treated when 15 or more small (<0.25 inch) larvae or 20 damaged squares are found per 100 plants. After first bloom, in non-Bt cotton that has not been treated previously, insecticide should be applied at 20 or more eggs, 3 small larvae, or 5% damaged squares per 100 plants. Tobacco budworms have been documented to be resistant to multiple insecticide classes, so insecticide choices are limited in non-Bt cotton. Pyrethroid-resistant tobacco budworms have been detected in cotton in South Carolina and should be considered resistant to that class of chemistry.

Bollworm (corn earworm) is a key insect pest of cotton in South Carolina because it will infest most fields in the state every year. Infestations are most likely to occur in July after moths that have emerged from corn fields begin to deposit eggs on cotton plants. In the Coastal-Plain region, moth flights will usually begin within the period from 6 to 20 July, with the earliest flights occurring in the Savannah Valley area. Bollworms have generally been less of a threat in the Piedmont region, where infestations generally don't materialize before the last week in July. Insecticide applications will be triggered when the numbers of eggs, bollworms, or damage reach economic levels (economic thresholds). Scouting for eggs and hatching larvae is a responsibility of a cotton scout. After bollworm moths have deposited their eggs on cotton plants, the eggs will begin hatching in about three days. Eggs are deposited singly and generally on the upper leaf surfaces near plant terminals. By mid-July or later, moths may deposit a higher percentage of eggs lower on the plants on leaves, squares, stems, and even blooms or dried blooms (bloom tags). Scouts should check whole plants for bollworm eggs and larvae and examine the following fruiting forms on each plant: a white bloom, a pink bloom and the two smallest bolls. Remove bloom tags to look for damage on the tips of small bolls where bollworm larvae often gain entry. Historically, in first-generation Bt cotton, an insecticide treatment was recommended when 30 or more small (<0.25 inch in length) larvae were found per 100 plants, and the threshold for bollworms that were not controlled with Bt cotton (commonly called "escaped worm threshold") was three larger (≥ 0.25 inch in length) larvae per 100 plants or 5% damaged bolls. Treatment thresholds for bollworm in second-generation Bt cotton are being

re-evaluated, but the best available options are to consider intervention when egg numbers approach 100 or more per 100 plants for consecutive weeks, when three large (≥ 0.25 inch in length) larvae are found per 100 plants, or when 5% of bolls are damaged by bollworm. After first bloom, in non-Bt cotton, insecticide should be applied at 20 or more eggs, 3 small larvae, or 5% damaged squares per 100 plants. Cotton fields should be checked at least once a week, from seedling emergence through the first week in July. More frequent scouting is recommended from early July through mid August, primarily to detect hatch-out of bollworm larvae. Thereafter, weekly field visits should continue until most plants have reached a stage of maturity considered relatively safe from insect damage.

In 1996 pyrethroid-resistant bollworms were found in cotton fields in Hampton County near Estill, SC. Vial tests conducted with moths trapped in the Savannah Valley in 1997 confirmed the presence of resistance. Also, pyrethroid resistance was confirmed from fields in Orangeburg and Calhoun Counties in August of 1997. Both of these fields were characterized by the presence of numerous large bollworms following multiple applications of pyrethroids. Pyrethroid resistance was documented in five locations below the lakes in 1998 from bollworms collected in fields where there had been control problems. Recent studies have shown that rates of survival shown by bollworm in adult vial tests and reported from confirmed field collections after exposure to pyrethroids are increasing, indicating that pyrethroid-resistance genes are still present. Efforts to monitor pyrethroid resistance will continue, but rotation of insecticide class is recommended as part of a resistance management approach. Avoiding consecutive applications of pyrethroids for bollworm would be one possible tactic to delay development of resistance. See detailed recommendations for bollworm insecticides that can be used as alternatives to pyrethroids.

Beet and fall armyworms usually do not occur until late July or early August, as neither species is known to overwinter in South Carolina. Moths of both species lay eggs in masses of 80 to 100 on the undersides of leaves. Newly emerged fall armyworms (first instars) tend to feed singly on the younger growth within the middle portion of a plant. Small beet armyworms are gregarious, and will feed in clusters on the undersides of leaves through third instars. When small larvae feed on the inner surfaces of square bracts, the etchings will be visible externally. Fall armyworms are often found in blooms, where they feed on floral tissue and pollen. Like bollworms, fall armyworms will eventually damage larger bolls. Beet armyworms feed on squares and blooms, but they usually do not bore into bolls. Large beet armyworms are capable of completely defoliating non-Bt cotton plants. Second- and third-generation Bt cotton varieties do a very good job in controlling armyworms, but they are not immune to injury, and subtle differences in efficacy exist among the technologies (see GENETIC INSECT CONTROL below).

Spider mites are occasionally a problem in South Carolina cotton. Infestations of mites are often flared by extremely hot and dry weather conditions. Applications of insecticides (e.g. acephate) for other pests may also flare infestations of spider mites by reducing the numbers of beneficial arthropods that prey upon them. Initial infestations occur from spider mites moving from wild host plants or other crops into border rows of cotton. Yellow speckling on the upper surfaces of leaves (in proximity to petiole attachment) will be the first indication of a mite infestation. As mites continue to feed on the undersides of leaves, the upper surfaces will become reddened. Early recognition of these symptoms, and spot treating infested areas, will often prevent spider mites from spreading throughout a field.

Stink bugs have piercing-sucking mouthparts that they use to pierce small bolls and suck sap from the seeds. Seed coats more or less collapse, and the attached lint often acquires a yellowish to brownish colored stain. Small, warty growths on the inside of a boll wall will generally mark the points of penetration. Warts typically form within 48 hours after penetration. Water-soaked lesions are signs of more recent penetrations, where warts may not have had time to develop. Warts may never develop when a stink bug penetrates the boll wall, fails to find a seed, and then quickly withdraws its beak. Furthermore, warts do not form on bolls that have reached full size. Damaged bolls may open prematurely or become hard-locked. Usually only one or two locks will be damaged, but occasionally, if infestations are heavy, bolls may be completely hard locked. Boll damage is the main criterion used to evaluate infestations of stink bugs. A scout should randomly select 25 or more quarter-sized bolls, break them open, and check the inner walls of the bolls for the damage symptoms indicated above.

Care should be taken to ensure that all bolls examined are of the same age class because these will provide the most reliable estimate of the actual current damage in a field. When damage symptoms are present, look for adults and large nymphs by shaking plants over a beat cloth or into a plastic pan where they can be examined and identified. It is possible that plant bugs or other sucking insects might damage small bolls, so identification is important before action is taken. By the time a boll is 25 days old, it should be relatively safe from attack.

ACTION THRESHOLDS

Compare numbers on scouting reports to recommended action thresholds described in the remarks after each table in the insecticide recommendations section to help determine need for an insecticide treatment. One must also consider factors such as the stage of plant growth or whether the cotton is a Bt or not-Bt variety. For some insect pests, such as bollworm, insect numbers or damaged-square counts are provided to enable a grower to determine whether or not an insecticide application is warranted. Action thresholds are not well defined for every insect pest, and deciding whether or not to treat may be more difficult. In these situations, there is often a greater likelihood of treating a field when it is unnecessary. Threshold numbers are general in nature and are subject to professional interpretation. County agents and cotton consultants should have the expertise to help determine how these thresholds best apply to field situations on a particular farm.

RESISTANCE MANAGEMENT IN BT COTTON

The only cotton varieties with Bt technology available for 2015 will be those that contain more than one Bt gene (multiple Bt toxins), such as Bollgard II, WideStrike, WideStrike 3, and TwinLink varieties commercially available now. A structured cotton refuge is no longer required for Bt cotton, and this "natural refuge" option is available for any brand of cottonseed containing Bt technology.

<http://www.monsanto.com/products/pages/insect-resistance-management.aspx>

<http://www.dowagro.com/phytogen/stewardship/>

<https://www.bayercropscience.us/products/traits/twinlink/resistance-management>

GENETIC INSECT CONTROL

Trade name	Bollworm	Tobacco budworm	Beet armyworm	Fall armyworm	Soybean looper	Cutworm
Bollgard II	Excellent	Excellent	Excellent	Good	Excellent	Poor
Bollgard III*	Excellent	Excellent	Excellent	Excellent	Excellent	Poor
WideStrike	Good	Excellent	Excellent	Excellent	Good	Poor
WideStrike 3	Excellent	Excellent	Excellent	Excellent	Excellent	Poor
TwinLink	Excellent	Excellent	Excellent	Good	Excellent	Poor
TwinLink Plus*	Excellent	Excellent	Excellent	Excellent	Excellent	Poor

Transgenic Bt varieties offer cotton growers a unique technological tool for the management of lepidopterous insect pests. There are differences in their relative effectiveness against several species that are common in South Carolina. *Future technologies near release.

COTTON INSECT CONTROL RECOMMENDATIONS

“Instant –View” Threshold Guide

Insect	Number per unit
Stink bugs (SB)	20% injury to medium-sized bolls; 10% during wk 3-5 of bloom; bugs present
Bollworms <i>2nd & 3rd generation Bt cotton</i>	After 1 st bloom, consider treatment soon after peak egg lay or > 1 egg/plant, 3 or more larger (>0.25 inch) larvae per 100 plants, or 5% damaged bolls
Bollworms <i>Non-Bt cotton</i>	After 1 st bloom: 20 or more eggs or 3 small (<0.25 inch) larvae per 100 plants or 5% damaged squares
Tobacco budworms (TBW) <i>Non-Bt cotton only – not found in Bt cotton</i>	Before 1 st bloom: 15 small (<0.25 inch) larvae per 100 plants or 20% damaged squares; after 1 st bloom: 20 eggs or 3 small larvae per 100 plants or 5% damaged squares
Thrips	2-4 thrips per plant (less if immatures) and damage present
Aphids	Plants severely infested and stressed with actively growing colonies present
Fall armyworms (FAW)	10 or more per 100 plants, checking blooms and bolls
Spider mites	50% of plants infested and stressed with actively growing colonies present

This quick-view threshold table was intended to be a quick reference for treatment thresholds for the most common insect pests of cotton in South Carolina. The sections described hereafter include detailed information about thresholds and specific insecticide recommendations.

THRIPS (AT PLANTING)

Product (at planting)	Product/acre	Lb ai/acre	Acre/gal	REI	PHI	Comments
aldicarb (R) Temik 15 G	3.5-5.0 lb	0.525-0.75	-	48 hr	90 d	In-furrow granular
thiamethoxam Cruiser Avicta Duo Acceleron (check coding)	- - - -	-	- - -	12 hr	-	Seed treatment
imidacloprid Gaucho 600 Aeris Acceleron (check coding)	- - - -	-	- - -	12 hr	-	Seed treatment
acephate Orthene/Acephate 97 Orthene/Acephate 90	16.0 oz 17.2 oz	0.97	- -	24 hr	21 d	In-furrow spray
phorate (R) Thimet 20 G	5.0 lb	1.0	-	48 hr	60 d	In-furrow granular
imidacloprid Couraze 4 F Couraze 2 F Admire Pro 4.6	10.55 oz 21.1 oz 9.2 oz	0.33	12.1 6.0 13.9	12 hr	14 d	In-furrow spray
Product (foliar sprays)	Product/acre	Lb ai/acre	Acre/gal	REI	PHI	Comments
dicrotophos (R) Bidrin 8 E	1.6-3.2 oz	0.1-0.2	40-80	6 d	30 d	3.2 oz limit pre-square
acephate Orthene/Acephate 97 Orthene/Acephate 90	3.0 oz 3.2 oz	0.18	- -	24 hr	21 d	
dimethoate Dimethoate 4 EC	4.0-8.0 oz	0.125-0.25	16-32	48 hr	14 d	
spinetoram Radiant 1 SC	1.5-3.0 oz	0.0117-0.0234	42.7-85.3	4 hr	28 d	Adjuvant recommended

The high rate of Temik should also provide some protection against nematodes and suppress early populations of aphids and spider mites. When cotton is planted after May 20, seed treatments have proven to be effective in limiting thrips damage to seedling cotton plants. Seed companies or distributors provide seed treatment products as optional coatings of cotton seeds. Avicta Complete Pak and Aeris have some activity on nematodes. Generally, a preventative insecticide used at planting will protect seedlings from severe stunting characteristic of thrips injury. Occasionally, however, conditions will be unfavorable for proper uptake of systemic insecticides (too cool, dry soil, excessive moisture, etc.), and plants can be severely damaged. **Foliar treatments will be most effective when applied to cotton seedlings prior to unfolding of the second true leaf.** A foliar insecticide treatment may be needed when two or more thrips are found per plant. Shake each plant (randomly select 25 or more) into a coffee cup or a similar utensil to facilitate counting. When most plants have severely damaged growing points and immature thrips are present, one or more foliar treatments may be needed to allow the plants to resume normal growth and development. Examine plants 5-7 days after the initial treatment, and treat again if immatures are still present on most plants. When the newly unfolded leaves of infested plants are free of damage, and plants appear to be growing at a normal rate, further applications of insecticides will have little benefit. Treatments applied beyond the four-leaf stage of growth may actually be counterproductive, as these would likely reduce beneficial populations and result in early-season problems with other pests.

CUTWORMS

Product	Product/acre	Lb ai/acre	Acre/gal	REI	PHI	Comments
chlorpyrifos (R) Lorsban 4 E Nufos 4 E Lorsban Advanced 3.755	1.5-2.0 pt 1.5-2.0 pt 1.5-2.0 pt	0.70-1.0 (0.75-1.0) (0.75-1.0) (0.70-0.94)	4.0-5.3 4.0-5.3 4.0-5.3	24 hr	14 d	
acephate Orthene/Acephate 97 Orthene/Acephate 90	12.0-16.0 oz 13.0-16.0 oz	0.73-0.97	- -	24 hr	21 d	
beta-cyfluthrin (R) Baythroid XL 1 EC	0.8-1.6 oz	0.0065-0.025	80-160	12 hr	0 d	
lambda-cyhalothrin (R) Karate Z 2.08 CS Karate 1 EC Silencer 1 EC Lambda-Cy 1 EC	0.96-1.28 oz 1.92-2.56 oz 1.92-2.56 oz 1.92-2.56 oz	0.015-0.02	100-133 50-67 50-67 50-67	24 hr	21 d	
cypermethrin (R) Ammo 2.5 EC Up-Cyde 2.5 EC	1.35-5.0 oz 1.35-5.0 oz	0.026-0.097	25.6-94.8 25.6-94.8	12 hr	14 d	
zeta-cypermethrin/ bifenthrin (R) Hero 1.24 EC	5.2-10.3 oz	0.05-0.1	12.4-24.6	12 hr	14 d	
esfenvalerate (R) Asana XL 0.66 EC	5.8-9.6 oz	0.03-0.05	13-22	12 hr	21 d	
gamma-cyhalothrin (R) Prolex 1.25 CS Declare 1.25 CS	0.77-1.02 oz 0.77-1.02 oz	0.0075-0.01	125-166 125-166	24 hr	21 d	
zeta-cypermethrin (R) Mustang Max 0.8 EC	1.28-1.92 oz	0.008-0.012	67-100	12 hr	14 d	
bifenthrin (R) Discipline 2 EC Brigade 2 EC Fanfare 2 EC Bifenture 2 EC	2.6-6.4 oz 2.6-6.4 oz 2.6-6.4 oz 2.6-6.4 oz	0.04-0.1	20-50 20-50 20-50 20-50	12 hr	14 d	

Treat when cutworms threaten to reduce plant populations below an acceptable level. The risk of infestations will be greater under reduced tillage conditions and in heavier soils, where cutworms can become established on existing vegetation and will move to cotton when it emerges. Destroying established vegetation 3 to 4 weeks before planting will often prevent cutworm problems. Some of the listed insecticides may be used as “rescue” treatments on cotton seedlings and some are labeled for pre-emergence use as either broadcast, banded, or in-furrow sprays. At-planting treatments may be warranted in situations where cutworms are already established and vegetation cannot be destroyed ahead of time. Often lower rates of insecticide can be use for these preventative at-plant treatments.

APHIDS

Product	Product/acre	Lb ai/acre	Acre/gal	REI	PHI	Comments
sulfoxaflor Transform 50 WG	0.75-1.0 oz	0.23-0.031	-	24 hr	14 d	
acetamiprid Assail 30 SG Assail 70 WP (Intruder 70)	1.5-2.5 oz 0.6-1.1 oz	0.025-0.05	-	12 hr	28 d	Ovicidal activity on caterpillars
dicrotophos Bidrin 8	8.0 oz	0.5	16	6 d	30 d	16 oz limit post bloom
flonicamid Carbine 50 WG	1.4-2.8 oz	0.044-0.088	-	12 hr	30 d	
thiamethoxam Centric 40 WG	1.25-2.0 oz	0.031-0.05	-	12 hr	21 d	5 oz limit for season
imidacloprid Couraze 4 F Couraze 2 F Admire Pro 4.6	1.0-2.0 oz 2.0-4.0 oz 0.9-1.7 oz	0.031-0.0625	64-128 32-64 75-142	12 hr	14 d	
clothianidin Belay 2.13	3.0-6.0 oz	0.05-0.1	21.3-42.6	12 hr	21 d	12 oz limit for season

Treat only when high numbers of aphids are severely infesting plants, populations are building, and the margins of terminal leaves are drooping. Aphids will cause more damage when plants are suffering from lack of moisture, and there are few signs of natural control agents. If there is evidence of widespread parasitism (dead aphids, tan colored and swollen in appearance) and/or fungal pathogens (diseased aphid bodies have a grayish-green colored fuzzy appearance) an insecticide should not be applied. Avoid unnecessary insecticide applications, as subsequent reductions in beneficial populations can result in damage from bollworm and fall armyworm.

PLANT BUGS (COTTON FLEAHOPPER AND TARNISHED PLANT BUG)

Product	Product/acre	Lb ai/acre	Acre/gal	REI	PHI	Comments
acephate Orthene/Acephate 97 Orthene/Acephate 90	4.1-12.3 oz 4.4-13.3 oz	0.25-0.75	-	24 hr	21 d	
imidacloprid Couraze 4 F Couraze 2 F Admire Pro 4.6	1.5-2.0 oz 3.0-4.0 oz 0.9-1.7 oz	0.031-0.0625	64-83 32-42.6 75-142	12 hr	14 d	
thiamethoxam Centric 40 WG	2.0-2.5 oz	0.05-0.0625	-	12 hr	21 d	5 oz limit for season
flonicamid Carbine 50 WG	2.8 oz	0.088	-	12 hr	30 d	
dicrotophos (R) Bidrin 8 E	4.0-8.0 oz	0.25-0.5	16-32	6 d	30 d	16 oz limit post bloom

Product (plant bugs cont.)	Product/acre	Lb ai/acre	Acre/gal	REI	PHI	Comments
oxamyl (R) Vydate 3.77 CLV	8.5-17.0 oz	0.25-0.5	7.5-15	48 hr	14 d	
clothianidin Belay 2.13	3.0-6.0 oz	0.05-0.1	21.3-42.6	12 hr	21 d	12 oz limit for season
novaluron Diamond 0.83 EC	9.0-12.0 oz	0.058-0.078	14.2-21.3	12 hr	30 d	Effective on nymphs only
sulfoxaflor Transform 50 WG	0.75-2.25 oz	0.23-0.071	-	24 hr	14 d	

Plant-bug injury to squares rarely causes economic problems in South Carolina. An economic problem could develop if an early-maturing variety was planted late, an average of one plant bug per foot of row is detected using a beat cloth or beat pan, or 25% or more of pinhead squares have been lost. Pyrethroid insecticides generally provide control of plant bugs when applied at stink bug/bollworm control rates. Avoid treating Bt cotton for plant bugs unless absolutely necessary in June and July as subsequent reductions in beneficial populations often trigger problems with bollworm or fall armyworm. Plant bugs can also injure small bolls like stink bugs. For combinations of plant bugs and stink bugs feeding on small bolls, use boll-injury treatment thresholds for stink bugs.

ARMYWORMS (BEET AND FALL ARMYWORM)

Product	Product/acre	Lb ai/acre	Acre/gal	REI	PHI	Comments
emamectin benzoate (R) Denim 0.16 EC (BAW) Denim 0.16 EC (FAW)	6.0-8.0 oz 8.0-12.0 oz	0.0075-0.015	16-21.3 10.7-16	12 hr	21 d	Suppression of spider mites
indoxacarb Steward 1.25 EC	9.2-11.3 oz	0.09-0.11	11.5-14	12 hr	14 d	
methoxyfenozide Intrepid 2 F	4.0-10.0 oz	0.0625-0.156	12.8-32	4 hr	14 d	Higher rates for FAW
novaluron Diamond 0.83 EC	6.0-12.0 oz	0.039-0.078	10.7-21.3	12 hr	30 d	
spinosad Tracer 4 SC Blackhawk 36 WG	2.14-2.9 oz 2.4-3.2 oz	0.067-0.09 0.054-0.072	44-60 -	4 hr	28 d	Existing stocks of Tracer
methomyl (R) Lannate 2.4 LV (FAW)	1.5-2.25 pt	0.45-0.675	3.6-5.3	3 d	15 d	May redden leaves
chlorantraniliprole Coragen 1.67 SC Prevathon 0.43 SC	3.5-7.0 oz 14.0-27.0 oz	0.045-0.09	18.3-36.5 4.7-9.1	4 hr	21 d	5-d interval/application
flubendiamide Belt 4 SC	2.0-3.0 oz	0.0625-0.094	42.6-64	12 hr	28 d	3 appl limit per season

Control of fall armyworms (FAW) may be justified when 10 or more larvae are found per 100 plants. Check blooms for the presence of FAW and look for feeding symptoms on boll bracts in the lower canopy. For beet armyworms (BAW) consider applying an insecticide when there are larvae present in noticeable numbers and damage is easily observed. Populations of BAW can develop on pigweeds in the field and move to cotton and overcome the Bt toxins. Cotton with two Bt toxins (i.e. Bollgard II or WideStrike) should provide good control of armyworms. Pyrethroids applied for control of stink bugs and bollworm will also provide some degree of control of eggs and newly hatched armyworms; however, after the worms have fed on cotton plants, these materials will be less effective. Best control is achieved when applications of insecticide are timed to coincide with egg hatch and emerging larvae.

BOLLWORM

Product (pyrethroids)	Product/acre	Lb ai/acre	Acre/gal	REI	PHI	Comments
bifenthrin (R) Discipline 2 EC Brigade 2 EC Fanfare 2 EC Bifenture 2 EC	2.6-6.4 oz 2.6-6.4 oz 2.6-6.4 oz 2.6-6.4 oz	0.04-0.1	20-50 20-50 20-50 20-50	12 hr	14 d	Control of spider mites at high rates
beta-cyfluthrin (R) Baythroid XL 1 EC	1.6-2.6 oz	0.0125-0.02	49-80	12 hr	0 d	
lambda-cyhalothrin (R) Karate Z 2.08 CS Karate 1 EC Silencer 1 EC Lambda-Cy 1 EC	1.6-2.5 oz 3.2-5.12 oz 3.2-5.12 oz 3.2-5.12 oz	0.025-0.04	50-80 25-40 25-40 25-40	24 hr	21 d	
cypermethrin (R) Ammo 2.5 EC Up-Cyde 2.5 EC	2.0-5.0 oz 2.0-5.0 oz	0.04-0.1	25-64 25-64	12 hr	14 d	
zeta-cypermethrin/ bifenthrin (R) Hero 1.24 EC	5.2-10.3 oz	0.05-0.1	12.4-24.6	12 hr	14 d	
esfenvalerate (R) Asana XL 0.66 EC	9.6 oz	0.05	13	12 hr	21 d	
gamma-cyhalothrin (R) Prolex 1.25 CS Declare 1.25 CS	1.28-2.05 oz 1.28-2.05 oz	0.0125-0.02	63-100 63-100	24 hr	21 d	
zeta-cypermethrin (R) Mustang Max 0.8 EC	2.64-3.6 oz	0.017-0.0225	35-48	12 hr	14 d	
Product (non-pyrethroids)	Product/acre	Lb ai/acre	Acre/gal	REI	PHI	Comments
novaluron Diamond 0.83 EC	12.0-14.0 oz	0.078-0.09	9.1-10.6	12 hr	30 d	Apply at egg hatch
indoxacarb Steward 1.25 EC	11.3 oz	0.11	11.5	12 hr	14 d	
spinosad Tracer 4 SC Blackhawk 36 WG	2.14-2.9 oz 2.4-3.2 oz	0.067-0.09 0.054-0.072	44-60 -	4 hr	28 d	Existing stocks of Tracer
emamectin benzoate (R) Denim 0.16 EC	8.0-12.0 oz	0.01-0.015	10.7-16	12 hr	21 d	Spider mite suppression
methomyl (R) Lannate 2.4 LV	1.5-2.25 pt	0.45-0.675	3.5-5.3	72 hr	15 d	May redden leaves
profenofos (R) Curacron 8 E	12.0-16.0 oz	0.75-1.0	8-10.7	48 hr	14 d	Season max 2 pt/acre
flubendiamide Belt 4 SC	2.0-3.0 oz	0.0625-0.094	42.6-64	12 hr	28 d	3 appl limit per season
chlorantraniliprole Coragen 1.67 SC Prevathon 0.43 SC	5.0-7.0 oz 20.0-27.0 oz	0.065-0.09	18.3-25.6 4.7-6.4	4 hr	21 d	5-d interval/ application

To reduce selection pressure for resistance in bollworm, avoid using pyrethroid insecticides before 1 July, unless infestations are extremely high. In transgenic cotton varieties that contain Bt endotoxins, an insecticide treatment should not be needed before first bloom. Transgenic Bt cotton varieties that have two endotoxins (Bollgard II and WideStrike) have increased efficacies against bollworms; however, under potential situations of very heavy pressure from bollworm, second-generation Bt technologies, particularly WideStrike, can incur

significant injury and losses if not protected with supplemental/timely application(s) of insecticide. To control escaped worms in Bt cotton, an insecticide treatment should be applied when 3 or more larger (>0.25 inch) worms are found per 100 plants or 5% of small bolls are damaged. Also, entire plants can be examined for eggs to determine pending pressure. Insecticide application can be justified if peak egg lay exceeds 1 egg per plant. On each plant a scout should examine a white bloom, a pink bloom, and the two smallest bolls. If dried blooms (bloom tags) adhere to small bolls, remove them and look for larvae boring into the boll tips. AFTER FIRST BLOOM, in non-Bt cotton that has not been previously treated, apply an initial insecticide treatment when 20 eggs or 3 small larvae are found per 100 plants or at 5% damaged squares. On non-Bt cotton, two treatments might be required to control bollworms following the initial moth flight in July. AFTER MID-AUGUST, consider the maturity of the crop in determining the need for a treatment. For example, 3 small worms or 5% damaged squares may still be an applicable threshold in late-maturing non-Bt cotton (early- to mid-bloom stage of development), but this infestation level could be tolerated in cotton that is nearing cutout, where most bolls are too mature to be damaged by bollworm.

BUDWORM (TOBACCO BUDWORM)

Product	Product/acre	Lb ai/acre	Acre/gal	REI	PHI	Comments
Bt Cotton	-	-	-	-	-	
spinosad Tracer 4 SC Blackhawk 36 WG	1.4-2.9 oz 1.6-3.2 oz	0.044-0.09 0.036-0.072	44-91.4 -	4 hr	28 d	Existing stocks of Tracer
indoxacarb Steward 1.25 EC	11.3 oz	0.11	11.5	12 hr	14 d	
novaluron Diamond 0.83 EC	12.0-14.0 oz	0.078-0.09	9.1-10.6	12 hr	30 d	Apply at egg hatch
methomyl (R) Lannate 2.4 LV	1.5-2.25 pt	0.45-0.675	3.5-5.3	72 hr	15 d	May redden leaves
profenofos (R) Curacron 8 E	12.0-16.0 oz	0.75-1.0	8-10.7	48 hr	14 d	
emamectin benzoate (R) Denim 0.16 EC	8.0-12.0 oz	0.01-0.015	10.7-16	12 hr	21 d	Spider mite suppression
flubendiamide Belt 4 SC	2.0-3.0 oz	0.0625-0.094	42.6-64	12 hr	28 d	3 appl limit per season
chlorantraniliprole Coragen 1.67 SC Prevathon 0.43 SC	5.0-7.0 oz 20.0-27.0 oz	0.065-0.09	18.3-25.6 4.7-6.4	4 hr	21 d	5-d interval/ application

Varieties containing Bt endotoxins will provide excellent control of tobacco budworm. Insecticides listed for tobacco budworm will provide effective alternatives to the pyrethroids for early- to late-season control where there have been control failures, and for use in resistance management. Indoxacarb and spinosad will conserve beneficial insects and spiders. Spinosad and all of the pyrethroids have activity on eggs of bollworm/tobacco budworm. When treatments are applied using an egg threshold, some eggs will be killed prior to larval emergence. Steward has low ovicidal activity, but when applied to eggs in the blackhead stage, larvae may be killed soon after emergence from consuming the eggshells. BEFORE FIRST BLOOM, in cotton varieties that do not contain the Bt endotoxin(s), treat when 15 small (<0.25 inch) larvae are found per 100 plant terminals, or 20% of squares are damaged. AFTER FIRST BLOOM, in non-Bt cotton, insecticide should be applied at 20 or more eggs, 3 small larvae, or 5% damaged squares per 100 plants.

SOYBEAN LOOPER AND CABBAGE LOOPER

Product	Product/acre	Lb ai/acre	Acre/gal	REI	PHI	Comments
spinosad Tracer 4 SC Blackhawk 36 WG	2.14-2.9 oz 2.4-3.2 oz	0.067-0.09 0.054-0.072	44-60 -	4 hr	28 d	Existing stocks of Tracer
indoxacarb Steward 1.25 EC	6.7-9.2 oz	0.065-0.09	14-19	12 hr	14 d	
novaluron Diamond 0.83 EC	6.0-12.0 oz	0.039-0.078	10.7-21.3	12 hr	30 d	
methoxyfenozide Intrepid 2 F	4.0-10.0 oz	0.0625-0.156	12.8-32	4 hr	14 d	
emamectin benzoate (R) Denim 0.16 EC	8.0-12.0 oz	0.01-0.015	10.7-16	12 hr	21 d	Spider mite suppression
flubendiamide Belt 4 SC	2.0-3.0 oz	0.0625-0.094	42.6-64	12 hr	28 d	3 appl limit per season

Apply an insecticide treatment when there is 25% or more defoliation and harvestable bolls are still developing. There are two species of loopers that defoliate cotton. The cabbage looper is generally controlled by any of the listed insecticides. The soybean looper is more difficult to control and is resistant to most insecticides. Varieties producing two or more Bt toxins will provide very good control of loopers.

SPIDER MITES

Product	Product/acre	Lb ai/acre	Acre/gal	REI	PHI	Comments
chlorpyrifos (R) Lorsban 4 E Nufos 4 E Lorsban Advanced 3.755	16.0 oz 16.0 oz 16.0 oz	0.47-0.50 (0.50) (0.50) (0.47)	8 8 8	24 hr	14 d	Do not graze treated areas or use gin trash as feed
bifenthrin (R) Discipline 2 EC Brigade 2 EC Fanfare 2 EC Bifenture 2 EC	3.8-6.4 oz 3.8-6.4 oz 3.8-6.4 oz 3.8-6.4 oz	0.06-0.1	20-33.7 20-33.7 20-33.7 20-33.7	12 hr	14 d	Higher rates required for adequate control
dicofol Dicofol 4 E	1.0-1.5 qt	1.0-1.5	2.7-4	12 hr	30 d	Last use by 31 Oct 2016
propargite Comite 6.55 Comite II 6	16.0-32.0 oz 20.0-36.0 oz	0.82-1.69	4-8 3.55-6.4	7 d	50 d	Do not apply until plants are 12 in tall
spiromesifen Oberon 2 SC Oberon 4 SC	8.0-16.0 oz 4.0-8.0 oz	0.125-0.25	8-16 16-32	12 hr	30 d	Per season 32 oz limit 16 oz limit
etoxazole Zeal 72.7 WSP	0.66-1.0 oz	0.03-0.045	-	12 hr	28 d	Max of 1 application
abamectin (R) Agri-Mek 0.15 EC Zoro 0.15 EC	8.0-16.0 oz 8.0-16.0 oz	0.009-0.0188	8-16 8-16	12 hr	20 d	32 oz limit per season
feproximate Portal 0.4	16.0-32.0 oz	0.05-0.1	4-8	12 hr	14 d	Limit of 2 pt per season

Infestations of spider mites usually appear in border rows of a field or sometimes in isolated spots within a field. When mites first appear, treating border rows or spot treating may prevent outbreaks.

STINK BUGS

Product (non-pyrethroids)	Product/acre	Lb ai/acre	Acre/gal	REI	PHI	Comments
dicrotophos (R) Bidrin 8 E	6.0-8.0 oz	0.375-0.5	16-21.3	6 d	30 d	16 oz limit post bloom
acephate Orthene/Acephate 97 Orthene/Acephate 90	0.52-0.77 lb 0.55-0.83 lb	0.5-0.75	- -	24 hr	21 d	
oxamyl (R) Vydate 3.77 CLV	13.6-17.0 oz	0.4-0.5	7.5-9.4	48 hr	14 d	
novaluron Diamond 0.83 EC	9.0-14.0 oz	0.058-0.09	9.1-14.2	12 hr	30 d	Effective on nymphs only
Product (pyrethroids)	Product/acre	Lb ai/acre	Acre/gal	REI	PHI	Comments
bifenthrin (R) Discipline 2 EC Brigade 2 EC Fanfare 2 EC Bifenture 2 EC	2.6-6.4 oz 2.6-6.4 oz 2.6-6.4 oz 2.6-6.4 oz	0.04-0.1	20-50 20-50 20-50 20-50	12 hr	14 d	Control of spider mites at high rates
<i>beta</i> -cyfluthrin (R) Baythroid XL 1 EC	1.6-2.6 oz	0.0125-0.02	49-80	12 hr	0 d	
<i>lambda</i> -cyhalothrin (R) Karate Z 2.08 CS Karate 1 EC Silencer 1 EC Lambda-Cy 1 EC	1.6-2.5 oz 3.2-5.12 oz 3.2-5.12 oz 3.2-5.12 oz	0.025-0.04	50-80 25-40 25-40 25-40	24 hr	21 d	
cypermethrin (R) Ammo 2.5 EC Up-Cyde 2.5 EC	2.0-5.0 oz 2.0-5.0 oz	0.04-0.1	25-64 25-64	12 hr	14 d	
<i>zeta</i> -cypermethrin/ bifenthrin (R) Hero 1.24 EC	5.2-10.3 oz	0.05-0.1	12.4-24.6	12 hr	14 d	
esfenvalerate (R) Asana XL 0.66 EC	9.6 oz	0.05	13	12 hr	21 d	
<i>gamma</i> -cyhalothrin (R) Prolex 1.25 CS Declare 1.25 CS	1.28-2.05 oz 1.28-2.05 oz	0.0125-0.02	63-100 63-100	24 hr	21 d	
<i>zeta</i> -cypermethrin (R) Mustang Max 0.8 EC	2.64-3.6 oz	0.017-0.0225	35-48	12 hr	14 d	
<i>alpha</i> -cypermethrin (R) Fastac 0.83 EC	3.6 oz	0.023	35.5	12 hr	21 d	

Treat when medium-sized bolls display symptoms of feeding injury by week of bloom (50, 30, 10, 10, 10, 20, 30, 50%) and stink bugs are present. Begin scouting for stink bugs when small bolls appear. Consider using a more aggressive (i.e. 10%) threshold during weeks 3-5 of bloom, as bolls developing during this growth stage are particularly susceptible. Randomly select at least 25 bolls (at least a quarter [1 inch] in diameter) per field (add 1 additional boll for each acre exceeding 25 acres). Break each boll open and examine the carpal walls, lint, and seeds for injury symptoms. Look for the presence of warty growths on the carpal walls and for discolored seed and lint. To ensure the accuracy of this sampling method, do not deviate from weekly checking of quarter-size diameter bolls. One may also rate an infestation based upon numbers of stink bugs by using a 3-ft beat cloth. When this method is used, an insecticide treatment will be warranted for 1 or more stink bugs per 6 feet of row. Carefully approach and shake the plants on at least 30 feet of row (10, 3-ft samples). Pyrethroids applied for bollworm control will generally provide control of stink bugs as well. Bidrin should be used in a pyrethroid tank-mix in fields with infestations predominated by brown stink bugs. Be especially vigilant for stink bugs when no treatments are being applied for control of caterpillars.

WHITEFLIES

Product	Product/acre	Lb ai/acre	Acre/gal	REI	PHI	Comments
acephate Orthene/Acephate 97 Orthene/Acephate 90	8.2-16.5 oz 8.9-17.8 oz	0.5-1.0	- -	24 hr	21 d	
acetamiprid Assail 30 SG Assail 70 WP Intruder 70 WSP	4.0-5.3 oz 1.7-2.3 oz 1.7-2.3 oz	0.075-0.1	- - -	12 hr	28 d	Ovicidal activity
thiamethoxam Centric 40 WG	2.0-2.5 oz	0.05-0.0625	-	12 hr	21 d	5 oz limit for season
imidacloprid Couraze 4 F Couraze 2 F Admire Pro 4.6	1.0-2.0 oz 2.0-4.0 oz 0.9-1.7 oz	0.031-0.0625	64-128 32-64 75-142	12 hr	14 d	
pyriproxyfen Knack 0.86	8.0 oz	0.05375	16	12 hr	28 d	An IGR with slow activity

Treat fruiting cotton when 50% of plant terminals have whiteflies present in heavy clusters on the undersides of leaves and immatures are present. Treat mature cotton when clusters of whiteflies are present in terminals, bolls are opening, and honeydew is found. Infestations are rare and usually bandedwinged whiteflies. Use higher rates for suppression of difficult-to-control silverleaf whiteflies.

MULTIPLE PESTS – PRE-MIXED OR CO-PACKAGED PRODUCTS

Product	Product/acre	Lb ai/acre	Acre/gal	REI	PHI	Comment
imidacloprid/ <i>beta</i> -cyfluthrin (R) Leverage 360	2.8-3.2 oz	0.066-0.075	40-45.7	12 hr	14 d	Pre-mixed
thiamethoxam/ <i>lambda</i> -cyhalothrin (R) Endigo 2.06 ZC	3.5-6.0 oz	0.056-0.096	21.3-36.6	24 hr	21 d	Pre-mixed
imidacloprid/bifenthrin (R) Brigadier 2 SC	3.8-7.7 oz	0.06-0.12	16.6-33.7	12 hr	14 d	Pre-mixed
spinosad/ <i>gamma</i> -cyhalothrin (R) Consero CP	1 unit per 32-45 acres	-	-	24 hr	28 d	Co-pack
dicrotophos/bifenthrin (R) Bidrin XP II	10.5-12.8 oz	0.41-0.5	-	6 d	30 d	Co-pack
chlorantraniliprole/ <i>lambda</i> -cyhalothrin (R) Besiege 1.25 ZC	6.5-12.5 oz	0.063-0.122	10.2-19.7	24 hr	21 d	Pre-mixed
chlorpyrifos/ <i>gamma</i> -cyhalothrin (R) Cobalt 2.55	26.0-38.0 oz	0.518-0.757	3.37-4.9	24 hr	21 d	Pre-mixed
chlorpyrifos/ <i>lambda</i> -cyhalothrin (R) Cobalt Advanced 2.63	16.0-38.0 oz	0.328-0.78	3.37-8.0	24 hr	21 d	Pre-mixed
bifenthrin/avermectin (R) Athena 0.87	10.0-17.0 oz	0.068-0.115	7.5-12.8	12 hr	20 d	Pre-mixed
diflubenzuron/ <i>lambda</i> -cyhalothrin (R) DoubleTake 3	3.0-4.0 oz	0.07-0.0938	32-42.7	24 hr	21 d	Pre-mixed
methoxyfenozide/spinetoram Intrepid Edge 3	4.0-8.0 oz	0.094-0.188	16-32	4 hr	28 d	Pre-mixed

For control of multiple pests exceeding thresholds, including but not limited to various combinations of the following: bollworm, beet and fall armyworms, grasshoppers, aphids, plant bugs, stink bugs, and spider mites.

ai = active ingredient; **(R)** = Restricted use; **REI** = re-entry interval; **PHI** = pre-harvest interval

TREATMENT TIPS

- Scout your fields regularly to determine insect population levels and to time insecticide applications.
- Where control problems occur, check your sprayer calibration and insecticide rates to ensure they are correct.
Be especially suspicious of high percentages of bollworms surviving multiple applications of pyrethroids.
Suspected resistance problems should be reported to county agents immediately.
- Use high rates, and avoid low rates.
- Insecticides will be much more effective against bollworms when applied within the first 48 hr after hatch-out.
- Use higher spray volumes during hot weather and when control of bollworms is difficult.
- Applying insecticides in oil may increase their effectiveness during unusually hot weather or during rainy weather.
- Hollow cone nozzles are superior to flat fan nozzles in getting good coverage of leaves and other plant parts. TX6 or TX8 tips provide excellent coverage at 7 to 10 gallons per acre and 60 psi.
- CAUTION: It is prohibited to spray blooming cotton with pyrethroids when bees are actively foraging.