

## 12. MANAGING INSECTS ON COTTON

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Cotton insect pests can cause significant direct yield losses from the time of seedling emergence through boll maturity. In addition, pests can indirectly cause loss; for example, bollworms and plant bugs can lower lint quality by delaying maturity, and stink bugs can both delay maturity and transmit boll rot pathogens. However, producers can minimize insect damage by following these six practices:

- Recognize the major pest and beneficial insects.
- Follow recommended scouting procedures.
- Follow recommended thresholds.
- Apply insecticides quickly after a threshold has been reached.
- Follow insecticide-use recommendations designed to delay resistance.
- Use cultural and biological controls to limit crop damage from pests when possible.

Insect control costs in North Carolina are lower than in some other regions of the Cotton Belt (such as the Mississippi Delta), providing our producers with an economic advantage over their counterparts elsewhere. However, thrips, plant bug, cotton aphid, bollworm, stink bug, or spider mite feeding can sometimes cause significant yield losses.

The Boll Weevil Eradication Program began in 1978 on approximately 15,000 acres in northeastern North Carolina and resulted in the eradication of the boll weevil from the Southeast, the mid-South and most of the far West. However, boll weevils may still be unintentionally transported back into weevil-free areas. These “hitchhikers” are most often the result of passive transport aboard vehicles, or on cotton equipment such as cotton pickers, module builders, and module haulers. The Southeastern Boll Weevil Foundation supervises our large-scale, pheromone-trap-based Boll Weevil Containment monitoring program; however, this program is implemented by the NCDA&CS.

As boll weevils have not been found in North Carolina for the past 26 years, the pheromone trapping density and associated containment costs have been reduced during this period. North Carolina cotton producers will likely be assessed a fee of approximately \$0.75 or less per acre during 2025.

## EARLY-SEASON INSECT MANAGEMENT

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Thrips are usually in the top three of North Carolina's most economically damaging insect pests of cotton. Because early season thrips injury has the potential to cause significant yield losses and maturity delays, this pest group must be controlled every year.

Thrips feed on cotton seedlings by puncturing the outer cells of young leaves and buds and consuming the plant juices within. Injury frequently results in ragged-looking plants with crinkled leaves. This injury stunts growth and can result in fruiting at higher positions, causing maturity delays and reduced yields. Injury resulting from thrips can sometimes be confused with, or exacerbated by, injury from preemergent herbicides. Furthermore, adult females prefer to lay their eggs in fleshy cotyledons. Just a few larval thrips emerging from these eggs can cause significant injury to true leaves as they are expanding by directing damage to the growing point. To prevent maturity delays or yield loss, thrips must be managed before injury is noticed. It is therefore critical to document the presence of thrips before a treatment decision is made.

Injury from thrips can also be worsened by cool conditions in the spring, as slow-growing plants are exposed to thrips at a susceptible stage. In addition to cool weather, dry spring weather may inhibit the uptake of at-planting systemic insecticides (seed treatments or in-furrow insecticides). Dry weather may also result in the premature drying of alternate thrips hosts (such as wheat and weeds). This drying, in turn, may force large numbers of flying adult thrips to abandon these plants in search of younger, greener hosts, such as cotton seedlings that are already not taking up insecticides very well. Also, heavy or prolonged rains during the first few weeks after planting can speed the leaching of seed treatment or in-furrow insecticides, resulting in poor control and increasing the need for foliar applications.

Because of the high populations and the shorter growing season in North Carolina, thrips have the potential to cause significant yield losses and maturity delays. Growers must control them every year using programs that strive for excellence. Almost all cotton producers in North Carolina used a seed treatment for thrips control in 2024, either alone or in combination with a soil-applied systemic insecticide (such as Admire Pro or AgLogic in-furrow). These products typically provide some degree of protection from thrips, and most thrips-active portions are all in the neonicotinoid-class of insecticide chemistry, with the exception of AgLogic, which is a carbamate. Up until 2014, the thrips control provided by the different seed treatments was thought to be similar, on average, although a particular seed treatment could be more or less effective depending on environmental conditions. In 2014, however, it was discovered that some populations of our most common thrips pest of cotton (tobacco thrips) were more resistant to neonicotinoids than others. The same phenomenon was also documented in other states. We now know that resistance is widespread across the Cotton Belt, although on a local level, populations have a range of susceptibility. In practice, this finding means that you can expect neonicotinoid seed treatments, and possibly some in-furrow applications, to not work as well in some areas in 2025 as they have in the past. In some cases, we should expect complete field

failures with these products. Cotton varieties that express thrips-active *Bt* toxins (ThryvOn) is the newest pest management technology that can provide additional protection from crop injury.

In addition to seed treatments, or in-furrow products, we strongly recommend scouting for thrips in every field in the event that a foliar application may be needed. Even when a soil-applied systemic insecticide is used, thrips often occur in damaging numbers. As mentioned before, dry weather may slow the uptake and performance of systemic insecticides. Also, extended cool weather may delay plant growth, keeping the plants susceptible longer and exceeding the time frame of the product's effectiveness. In this case, the persistence of a product's activity can be very important. Furthermore, the method of application of the in-furrow insecticide is critical. Producers who can direct liquid insecticide on the seed itself in-furrow will have more success than those who do not.

When a systemic insecticide fails to control thrips, a foliar spray is often warranted. It is important not to spray unless needed since a spray may give rise to other problems. Aphid and mite populations may increase following a spray, for example. In most cases, the use of an at-planting insecticide, often followed by a foliar spray, is successful for thrips control. Foliar-spray-only approaches without using an at-planting insecticide are not recommended; an at-planting insecticide is far more persistent and sometimes produces higher yields. Sprays should be prioritized for fields with the highest risk for thrips infestation. An online calculator has been developed and validated from years of southeastern U.S. data ([products.climate.ncsu.edu/ag/cottontip](https://products.climate.ncsu.edu/ag/cottontip)). This calculator uses weather information from specific geographical areas to predict when thrips will be dispersing into cotton and how susceptible cotton seedlings will be to thrips injury. Hence, growers can use this tool to predict where cotton is most at risk on their farms, directing scouting and management efforts toward these areas.

Finally, ThryvOn cotton was approved for planting in 2023. ThryvOn varieties express a *Bt* toxin that deters tobacco thrips adult feeding and egg-laying. Unlike other *Bt* toxins, this trait is not acutely toxic to either adult or larval thrips species. Because of this, growers should expect to see both adult and larval thrips on ThryvOn cotton, but in greatly reduced numbers compared to non-ThryvOn cotton. Based on extensive field testing, however, growers should not use in-furrow or foliar insecticides in combination with ThryvOn cotton for thrips. In field studies, adding insecticidal seed treatments, in-furrow, or foliar insecticides to ThryvOn cotton can further reduce thrips numbers and minimize seedling injury. Nevertheless, combining insecticides with ThryvOn does not protect more yield, even under extreme thrips pressure and adverse environmental conditions.

ThryvOn cotton is packaged with an insecticidal seed treatment (imidacloprid) for thrips resistance management. Experimental results combined with modeling suggest that the rate of resistance to the *Bt* toxin expressed by ThryvOn cotton can be delayed when paired with an insecticidal seed treatment. Growers should not add additional insecticides to ThryvOn for thrips resistance management beyond what is provided by the company.

Prior to bloom, tarnished plant bugs, or *Lygus lineolaris*, injure cotton by feeding in tender terminals. This can lead to a condition called black flag. More commonly, they feed directly on small squares with their needlelike mouthparts, causing the squares to abort. When blooming begins, tarnished plant bugs continue to feed on squares. Feeding on larger squares may cause “dirty blooms,” which are white blooms with darkened pollen anthers and sometimes with small, raised, circular bumpy deformities (warts) or dead tissue on the flower petals. In addition, plant bug feeding on small bolls up to approximately 11 days old may cause external boll spotting and internal boll damage, such as callous growth (warts), deformed or rotted fruit, or small boll abortion. This boll injury is often identical to that caused by stink bugs. In recent years, this type of injury has become more common, especially in eastern North Carolina. Plant bugs are capable of causing all of the injury symptoms shown in Table 12-1.

**Table 12-1. Plant Bug and Stink Bug Injury to Cotton Plants**

Plant Stage	Plant Part	Bug Type	Injury Symptoms
Prebloom	Terminals	Plant bug	With heavy feeding, terminals may be deformed or killed (black flag), resulting in a loss of apical dominance (crazy cotton).
	Small squares		Squares yellowing, turning brown, then black, and finally aborting, leaving a scar at the fruiting site.
Blooming	Various squares		Small squares, same as above; larger squares with internal damage to pollen anthers (shows up as “dirty blooms”).
	White blooms	Darkened pollen anthers (dirty blooms from plant bug feeding on large squares); petal deformations.	
	Bolls	Plant bug, Stink bug	Aborted small bolls, external spotting, internal pinprick-like feeding “stings,” wart-like growths, and stained lint; may cause boll rots, hard lock.

Early-season monitoring for plant bug activity, especially retention counts of small squares (approximately 1/8-to-3/16-inch long, including bracts), is recommended. If square retention counts remain high (80% or more), further sampling for plant bugs is probably unnecessary at that time. If retention rates of small, upper, and other first- or second-position squares drop below the 80% level, further sampling for live plant bugs may be needed. One method of sampling for missing square positions is to find one randomly selected terminal square (or its missing position) and one first- or second-position square (or its missing position). Two or three nodes from the top of the plant should be inspected per plant from 25 randomly selected plants within a field (50 squares total). Sweep net sampling for plant bug adults and large nymphs typically involves taking 25 sweeps at eight to 10 locations per cotton field (greater than 50 feet from the field edge) and is recommended in combination with square retention samples before bloom. Be mindful of field edges along ditch banks, adjacent host plants such as weedy flowering fields and cutovers, or where Irish potatoes or a substantial acreage of corn is present, especially in eastern counties. The above areas are likely sources of migrating adult plant bugs, but should

not be oversampled (nor overlooked). Smaller fields with more edges, later planted fields, and fields in areas with more double-cropped soybean and corn are at higher risk for tarnished plant bug infestation.

Once blooming has been underway for a week or more, square retention is a less-reliable indicator of possible plant bug feeding. At this point, the plant may lose squares due mostly to weather-related reasons and energy is directed to bolls, rather than from plant bugs. Late-season damage from plant bugs may be assessed by monitoring cotton plants for dirty blooms, for small bolls with signs of internal bug damage, and for adult and immature plant bugs via drop cloths. Examining open white flowers for the occurrence of one or more brown pollen anthers (dirty blooms) as an indication of recent plant bug feeding on large squares is not used to determine if a spray is needed, but as an indication of whether additional sampling is warranted. If the level of dirty blooms is in the range of 0 to 6%, additional sampling for plant bugs should not be needed for five to seven days. If the level of dirty blooms exceeds approximately 6%, additional sampling is advised. Dirty blooms should *never be used* to make a spray decision because there is a time lag from when the square was injured to when bloom occurs.

A black drop cloth (ground cloth) is the preferred method of direct sampling for plant bugs once blooming is underway. The drop cloth can detect plant bug nymphs that the sweep net cannot, and nymphs tend to be more prevalent during bloom. Black ground cloths are easily constructed by spraying the cloth part of the sampling device with black spray paint. The drop cloth threshold, confirmed by research in North Carolina, is 1.6 to 2.6 adult nymph (immature) plant bugs per 5 row feet (or the level contained in a 5-foot drop cloth sampled from each 2.5-row-foot-length on either side of the cloth) or a rounded-off level of two to three plant bugs per drop cloth sample. If nymphs, particularly late instars, are also easily seen (with the exception of the tiny first instars, which often experience high mortality), indicating that reproduction has occurred, the population is regarded as potentially more damaging to squares and young bolls.

We recommend that growers follow our *regional insecticide recommendations* ([cotton.ces.ncsu.edu/2022/06/regional-insecticide-recommendations-for-plant-bugs](https://cotton.ces.ncsu.edu/2022/06/regional-insecticide-recommendations-for-plant-bugs)), that were designed for different ranges of plant bug pressure. These recommendations optimize insecticidal use patterns for growers to find the sweet spot among efficacy, price, preservation of beneficial insects, and resistance management. Furthermore, ThryvOn cotton (mentioned earlier for thrips) expresses a *Bt* toxin that kills some portion of the tarnished plant bug population, but is mainly lethal to small nymphs (first and second instar). Like the mechanism for thrips, it serves as a deterrent to plant bug feeding and (probably) egg-laying. Field and laboratory research has shown that this toxin is not highly lethal to adult tarnished plant bugs. As a result, growers should not expect to see a reduction in adult tarnished plant bugs, especially earlier in the season when plant bugs migrate into cotton from other hosts. Furthermore, tarnished plant bugs can also reproduce on ThryvOn cotton. For this reason, we recommend that growers continue to scout and follow *the same economic threshold for tarnished plant bugs* in both non-ThryvOn and ThryvOn cotton.

## MIDSEASON INSECT MANAGEMENT

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Although technically beginning at first bloom, which can occur as early as late June, the start of the major mid-July-to-early-August bollworm (also known as corn earworm) moth flight usually signals the onset of potential bollworm and stink bug damage. The bollworm-tobacco budworm complex, typically composed of mostly bollworms, is the primary target for foliar insecticides in non-*Bt* cotton and *Bt* cotton (Bollgard 3, TwinLink Plus, and WideStrike 3). Fall and beet armyworms can cause fruit damage to non-*Bt* cotton, in most cases resulting from moving over from dried-down weed hosts (see additional note on fall armyworm). Plant bugs and stink bugs are now the dominant late-season pests in *Bt* cotton varieties. Because of the potential for severe boll damage from one or more of the above pests, and because cotton damaged at this time of year usually compensates little for boll damage, insect damage to bolls must be minimized during all or part of late July through mid-to-late August in North Carolina.

The first two generations of bollworms occur primarily on field corn. Third-generation (sometimes referred to as the second field, or F2, generation) moths usually emerge in large numbers from mid-July to early August when corn is drying, and they fly to the more attractive, blooming cotton. *To date, no tobacco budworms have survived on a Bt cotton plant in the field from a naturally occurring tobacco budworm population.* In contrast, bollworms have always survived at low levels in three-toxin *Bt* cotton and sometimes require overtreatment with foliar insecticide. This means that in heavy bollworm years, it will be economical to apply a foliar overspray to *Bt* cotton. The only effective insecticide class to eliminate these larvae using an egg-based threshold is the diamide class (contained in Besiege, Elevest, and Vantacor).

Growers should be prepared to spray *Bt* cotton if bollworms break through. Although Bollgard 3, TwinLink Plus, and WideStrike 3 varieties are highly effective against both tobacco budworm and bollworm, they still require follow-up sprays for larvae in heavy-pressure situations. Sprays directed against eggs will not be cost-effective, except in rare cases. Finally, bollworms are resistant to pyrethroids (bifenthrin is an example of a pyrethroid). Diamide-class insecticides (contained in Besiege, Elevest, and Vantacor) usually provide the best control for larvae once they have established in squares, blooms, or bolls.

Systematic, regular weekly scouting of cotton should be done for bollworms in *Bt* cotton. Weekly scouting is adequate until egg laying or light-trap catches increase, although light traps are ineffective for monitoring budworm moths. Check with your local Extension agent for possible light-trap counts for the major bollworm moth flights (in addition, the counts from multiple light traps are available online during the moth flight at [jpm.ces.ncsu.edu/trap-data](http://jpm.ces.ncsu.edu/trap-data)). Bollworms are more prevalent in fields where natural enemies have been eliminated due to broad-spectrum sprays directed at earlier season arthropods, such as aphids, spider mites, or plant bugs.

After the upper bolls that will be harvested have become difficult to cut with a pocketknife, the field is normally safe from further bollworm attack. Fields are also normally safe from further bollworm establishment when blooms and/or non-terminal squares are less than one per 1 to 2

row feet or more. Bollworm scouting can normally be stopped at that time—usually in mid-to-late August to early September, depending on the intensity of the moth flight and the maturity of cotton plants.

Due to our low late-season spray environment in North Carolina, the native green stink bug (*Chinavia hilare*), southern green stink bug (*Nezara viridula*) and the native brown stink bug (*Euschistus servus*) have become more abundant and damaging since the adoption of *Bt* varieties. The most yield-reducing damage to bolls takes place during weeks three to five or six of blooming. Brown marmorated stink bug (*Halyomorpha halys*) is a non-native invasive stink bug found throughout the state, but only in economically damaging numbers in the North Carolina western piedmont.

Stink bugs injure cotton by puncturing the carpal walls of bolls with their “beaks” and by feeding primarily on the soft, developing seeds. Heavy feeding on rare occasions destroys small bolls, causing them to abort. When stink bugs feed on slightly larger to medium-sized bolls (up to about three-and-a-half weeks old), they may introduce boll-rot pathogens, resulting in partially or entirely destroyed locks, hard-lock and a lower grade of harvested cotton. This damage is further expressed in cotton opening bolls under wet conditions. In contrast to the native green, southern green and brown stink bugs, both adult and nymph brown marmorated stink bugs can feed on bolls until maturity and even prefer larger-sized bolls.

Externally, boll injury is characterized by small, round, shallow, purplish depressions, usually in the 1/32-to-1/16-inch range. These spots tend to be larger than the tiny black gossypol gland spots. Internally, bug-injured bolls will often have a yellowish-to-tan or -brown stain in the seed areas, often, but not always, under the external feeding spots. Other injury symptoms include small wart-like growths or dark “pinprick” spots on the inside of the boll wall. We recommend counting both stained lint and warts as injury, but not external boll spotting or internal “pinpricks.” Internal boll injury can be present without obvious external evidence. Also, the external boll spotting caused by stink bugs and plant bugs may be difficult to separate from other kinds of spotting on the boll surface (for example, that caused by bloom tags that adhere to the top or side of the boll).

Because stink bug and plant bug damage to bolls is often indistinguishable, damaged bolls may be the result of feeding by either bug group.

The distribution of stink bugs and plant bugs in a cotton field may be uneven, with bug numbers and damage higher at field edges and in rank areas, but also dispersed in a clumpy manner throughout the cotton field. Do not oversample unrepresentative areas; however, they should not be ignored. Do not make decisions for the whole field based on edges or rank areas, but lump them into an average for the field.

A sample of 25 quarter-sized bolls (more in larger cotton fields—approximately one boll per acre) should be inspected during each scouting session, beginning at early boll development, but with an emphasis on weeks three through five or six of the bloom period.

To determine if a boll has been injured by stink bugs, the quarter-sized bolls should be either crushed by hand or cut open to examine the locks and inner boll wall surface. Except for “pinpricks,” count all internal boll injury, including stained or spotted lint and callous growth or inner boll wall warts. A threshold for native stink bugs of 50% internal injury is more appropriate than 30% during the first two weeks of blooming, as well as using higher thresholds later in the boll production period, when the ratio of larger, “safe” bolls to smaller, susceptible bolls increases (Table 12-2). Thresholds have not been established for the invasive brown marmorated stink bugs, and growers with brown marmorated stink bugs should use the thresholds established for native stink bugs as a guide.

**Table 12-2. Stink Bug Internal Boll Injury Thresholds**

<b>Week of Bloom</b>	<b>Injury Threshold (% Damage)</b>
1*	50 (treatment seldom justified)
2	30
3	10
4	10
5	10
6	20
7	30
8	50

\*Threshold seldom met during first week of bloom

Cotton growers and scouts in North Carolina can use the stink bug decision aid card to assess and manage stink bug (except brown marmorated, which can injure very mature bolls) injury based on thresholds for different cotton growth stages. This scouting decision aid was developed for use in the Southeast to encourage (1) enhanced adoption of stink bug scouting in cotton; (2) better field identification of stink-bug-induced boll damage symptoms; and (3) use of recommended scouting procedures. A card can be created by visiting the NC Cotton Insect Scouting Guide ([www.cottoninc.com/wp-content/uploads/2015/12/Stink-Bug-Decision-Aid.pdf](http://www.cottoninc.com/wp-content/uploads/2015/12/Stink-Bug-Decision-Aid.pdf)) and printing out the photos in the scouting card section. There is also a description on how to use it in the guide. The aid relies on the latest dynamic threshold for stink bugs in cotton based on week of bloom. The use of a simple decision aid can help producers and scouts in the following ways:

- Select the correct boll sizes for stink bug injury assessments.
- Recognize stink bug injury.
- Follow straightforward scouting steps.
- Utilize the “dynamic” threshold to avoid yield losses and minimize unnecessary insecticide use.

The stink bug decision aid card should improve stink bug management because the dynamic threshold is based on the cotton growth stages when the crop is most susceptible to stink bug

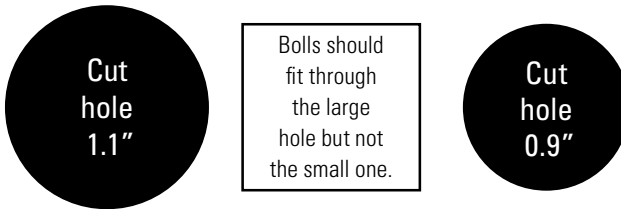
### Decision aid for stink bug thresholds in Southeast cotton

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- ❶ Pull random sample of quarter size diameter bolls, avoid field edges (boll sizes between 0.9" and 1.1").
- ❷ 1 boll/acre, no less than 25/field.
- ❸ Sort bolls into two piles: those with and those without obvious external lesions.
- ❹ Crack and inspect bolls with external lesions for internal damage (boll wall warts, stained seed, or lint).
- ❺ If threshold is not met for that week (see chart), check the remaining bolls for internal damage.
- ❻ Treat field only if the threshold is met for that week.

Week of bloom	Threshold (% internal boll damage)
1	50%
2	30%
3	10%
4	10%*
5	10%*
6	20%
7	30%
8	50%

\*Consult state guidelines for scouting intervals.

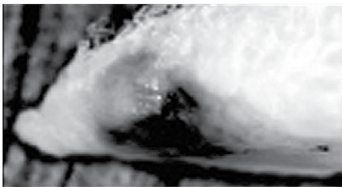


Bolls should fit through the large hole but not the small one.

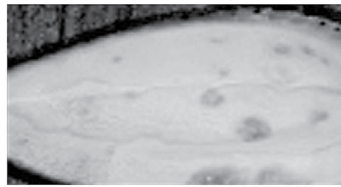


**Figure 12-1. Field decision aid showing scouting procedures, boll size selection range, and internal boll injury thresholds by week of bloom.**

### Decision aid for stink bug thresholds in Southeast cotton



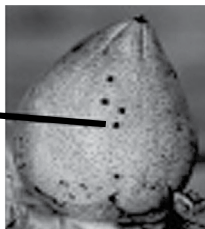
Stained seed and lint



Boll wall warts



External lesions



Quarter-size boll



**Figure 12-2. Aid showing external and internal stink bug injury symptoms.**

injury. The aid relies on lower thresholds during weeks of maximum susceptibility (weeks three through five of the bloom period) and higher thresholds during stages of lower vulnerability (weeks one to two and six to nine of the bloom period).

### ***Description and Use***

The decision aid card (Figure 12-1) recommends the following scouting procedures:

1. Select a random sample of the correct size bolls.
2. Assess an adequate number of bolls.
3. Sort the bolls into two piles, those with and without obvious external damage lesions.
4. Crack bolls between the thumb and forefinger or cut them open with a knife and inspect all internal boll wall surfaces for internal warts (not just areas visible from the initial crushing or knife cut), and examine all locks for stained lint. (Helpful hint: crack and inspect bolls with obvious external lesions first to determine if the internal damage threshold is met, as bolls with external lesions are more likely to be injured internally; assessing these bolls first can save time.)
5. If the threshold is not met, check the remaining bolls for internal injury.
6. Treat only if the threshold has been met for that week.

The measuring holes provide an efficient way to select correctly sized bolls. Cotton scouts should target bolls with an outside diameter between 0.9 to 1.1 inches. **Bolls of this size correlate best with recent stink bug injury.**

The recommended dynamic threshold is also listed by week of bloom. The asterisks for weeks four and five of the bloom period permit nuances in scouting frequency recommendations by the various southeastern states.

The card also provides images (in addition to the images of stink bug damage found on the aid itself) to help properly identify stink bug damage: internal warts and stained lint, and external damage lesions (Figure 12-2). As explained in procedure 3, above, external damage symptoms may be used to sort the pulled bolls into two groups.

If two or more consecutive scouting checks reveal stink bug damage at approximately two-thirds of the threshold level, treatment may be justified.

Once the damaged-boll threshold has been met, it may be helpful to determine if the brown stink bug, green stink bug, southern green stink bug, or brown marmorated stink bug are the predominate species in the field. This determination is important because brown stink bugs are more difficult to control with pyrethroids than green stink bugs, southern stink bugs, and brown marmorated stink bugs.

To determine which stink bug species is most prevalent, make general observations while scouting (in the case of high population levels), sample with a beat cloth (six beat cloth samples or more until adequate stink bug numbers are observed), or use a sweep net (sample until adequate numbers of

stink bugs are observed). Because these observations or samples are conducted solely to determine if the stink bugs are brown or green, they may be done quickly and include visual observations. For beat cloth sampling, a 3-by-3-foot or 2.5-by-3-foot beat cloth is unfurled between two adjacent rows, and the cotton plants in the two adjoining rows are beaten or shaken over the cloth, causing the large nymphs and adults to fall onto the cloth so they can be counted. Count any adult stink bugs seen flying if the color can be distinguished. In sweep net sampling, individual sweeps should be made with firm, pendulum-like motions (handle up, net down), swinging down with both hands through the upper middle canopy while walking down the row. If the sweeping motion is correct and vigorous enough, some bolls and leaves will usually be knocked into the net. In either of the above approaches of assessing live stink bugs, count adults and large nymphs. This quicker sampling may be stopped once an adequate sample (approximately 10 stink bugs) has been counted.

As the proportion of large “native stink bug safe” bolls increases relative to the smaller susceptible bolls during the end of July and throughout August and early September, the threshold may be raised, as indicated in Table 12-1 and in Figure 12-1. Scouting for stink bugs on *Bt* (or minimally treated) cotton once a week is recommended in most situations.

## ***Bt* COTTON**

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The three-toxin *Bt* varieties represented by Bollgard 3, TwinLink Plus, and WideStrike 3, manage only caterpillars, not other pest insects such as thrips, cotton aphids, plant bugs, and stink bugs. Also, different caterpillar pests are not controlled to the same degree. For example, field tests have shown that tobacco budworms attempting to feed on *Bt* cotton varieties in the field are all killed (at least for the time being). However, bollworms can damage squares and bolls, though generally at a low rate. Two-toxin *Bt* varieties typically provide good control of both armyworm species; however, see the later section on fall armyworms. In Bollgard 3, TwinLink Plus, and WideStrike 3 cotton, unless bollworm pressure is very high and chemical disruption has occurred (such as an overspray with Bidrin or Orthene just prior to or during the moth flight), sprays for bollworms may not be needed.

Similarly, ThryvOn cotton manages thrips species with varying success. As mentioned earlier, it is a deterrent to feeding and egg-laying for our main pest thrips species, tobacco thrips. However, it is moderately lethal to western flower thrips, a species that can be present in large numbers, especially in hot dry years. Furthermore, while it does not significantly impact beneficial impacts in the fields, there are some indications that ThryvOn cotton may be more susceptible to spider mites, especially if broad-spectrum insecticides like acephate (Orthene) are used early and mid-season. This provides more support for growers to follow our regional insecticide recommendations for tarnished plant bugs that were mentioned previously.

Because beneficial insects are not adversely affected by *Bt* cotton, their abundance and impact have increased in situations where disruptive insecticide applications are either less frequent or not made. Higher beneficial insect numbers present with fewer sprays for caterpillars have led to somewhat more effective suppression of third-generation bollworms and other caterpillars in *Bt* cotton varieties.

## **BOLLGARD II, TWINLINK, AND WIDESTRIKE COTTON**

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Essentially all cotton will be planted with three-protein *Bt* varieties (Bollgard 3, TwinLink Plus, and WideStrike 3). A non-*Bt* cotton refuge is not required since all North Carolina growers who plant *Bt* corn must plant 20% of their total corn acres to non-*Bt* hybrids. Resistance levels to the Vip3Aa toxin expressed in Bollgard 3, TwinLink Plus, and WideStrike 3 are increasing over time. Therefore, it is critical that corn growers plant non-*Bt* corn refuges to protect cotton, since many new hybrids also express Vip3Aa (Leptra and Trecepta).

The effectiveness of *Bt* proteins against North Carolina's major caterpillar pests is influenced by several factors, including the pest in question, the level of *Bt* susceptibility of the particular populations, the level of *Bt* protein expression in the fruiting structures, the level of supplemental, beneficial insect "help," and the phenology or maturity of the cotton crop. With irrigation, if high rates of nitrogen have been used, or if a beneficial-insect-reducing spray is applied just before or early in the bollworm moth flight (e.g., a spray for stink bugs), moderate to occasionally heavy bollworm establishment may occur with associated significant yield reductions.

Despite weaknesses against bollworm, three-toxin *Bt* varieties (Bollgard 3, TwinLink Plus, and WideStrike 3) also provide good-to-excellent control of beet and fall armyworms (see information under the fall armyworm section), and cabbage and soybean loopers, but not early-season cutworms.

## **SCOUTING COTTON FOR BOLLWORMS**

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A few cotton scouting suggestions are indicated below:

- Use damaged boll threshold for Bollgard 3, TwinLink Plus, and WideStrike 3: Boll sampling for larvae should consist of bloom tags, small bolls, and large bolls in the proportion that they occur in the field. It may be easier to keep track of this ratio by sampling and retaining 10 squares and 10 bolls while walking, then stopping within the field to evaluate the fruit. This process would be repeated 10 times for a total of 100 squares and 100 bolls. A single hole that penetrates the boll wall (they can be very small) constitutes a damaged boll. These bolls usually abscise from the plant.
- Use of "multiple pest thresholds" is encouraged: If sub-threshold levels of different pests add up to or exceed a one-pest threshold, treatment is advised (for example, 40% of the bollworm threshold and 75% of the stink bug threshold equal 115%, or more than 100% of the treatment threshold). Selection of the appropriate insecticide (Besiege alone, Elevest alone, or Vantacor tank-mixed with an additional insecticide with stink bug efficacy) should target products that are active against both insect groups.
- Scouting for other insects: Stink bugs and plant bugs have become more numerous and require more intensive scouting than in the past. Weekly scouting is recommended, with a subsample of fields assessed twice weekly to detect cases of rapid establishment.

Beneficial insects: Beneficial insects will likely be more abundant in untreated or less-treated *Bt* cotton if early season insects, such as plant bugs, have not been sprayed. Their identification and population levels should be at least informally monitored. Common beneficial insects include, but are not limited to, ladybugs, big-eyed bugs, pirate bugs, and lacewings.

## **THRYVON COTTON AND RESISTANCE MANAGEMENT**

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Increasingly more cotton will be planted to ThryvOn varieties. A non-*Bt* cotton refuge is not required as studies have indicated that natural refuge (non-crop and crop hosts that did not express the same *Bt* trait at ThryvOn) could help delay resistance. All ThryvOn varieties will also include an insecticidal seed treatment. This is because experimental data and modeling have demonstrated that an insecticidal seed treatment could help delay resistance to the *Bt* trait expressed in ThryvOn. Very little is known about resistance management to ThryvOn because it is not as lethal to the target pests as previous *Bt* traits targeting caterpillars. Therefore, we have few concrete recommendations to offer growers to delay resistance with one exception: The more often ThryvOn varieties are planted, the more selection pressure for resistance will occur.

## **MANAGEMENT OF MISCELLANEOUS INSECTS**

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### ***Aphids***

Cotton aphids are an occasional headache for cotton producers. Neonicotinoid insecticides (Assail, Belay, Centric, Admire Pro and, Strafer Max) are usually not effective. Because this insecticide class is used in both cotton seed treatments and for other cotton insects (such as plant bugs), aphid resistance to this class of insecticides is a concern. Alternative aphid insecticides (Carbine, Sefina, Sivanto, and Transform) are effective options with different modes of action than neonicotinoids.

Fortunately, high levels of aphid-mummifying parasites and the fungus *Neozygites fresenii* that in some cases hold or reduce aphids to subeconomic numbers are common in our region. In the past, these infestations established in the second or third week of July but more regularly established during August. The combination of predators, parasites, and fungi usually justifies our general recommendation not to treat cotton aphids with insecticides, except under dry, stressed conditions, very high aphid levels, and little or no evidence of mummies or the fungus. Note that the increase in early and mid-season sprays directed at plant bugs in recent years has reduced the incidence of parasites and predators that can hold aphids back. In cotton with open bolls, aphid-caused sooty mold or sticky cotton (from the heavy presence of honeydew) may become a problem, though not typically in the Southeast. After a defoliant has been applied, however, cotton aphids are typically only present at very low levels.

On the Aphid Rating Scale, a level of four or higher in cotton just before opening, plus honeydew presence, along with low levels of mummies or the fungus, may be a good indicator of the need to treat (see Aphid Rating Scale, Table 12-3). Treatments for cotton aphids have been low for the past two decades.

**Table 12-3. Aphid Rating Scale**

<b>Level</b>	<b>Condition</b>
0	No aphids.
1	Occasional plants with low numbers of aphids.
2	Plants with low numbers common; heavily infested plants rare; honeydew visible occasionally.
3	Most plants with some aphids; occasional plants heavily infested; honeydew easily visible in most areas of the field.
4	Heavily infested plants common; aphids clumped on upper leaves; honeydew common; cotton under stress.
5	Many heavily infested plants; infestations are on most plants in large areas of the field; cotton under stress.

### **Spider Mites**

Spider mite damage is rare in North Carolina in most years, but sometimes more common on cotton in the northeastern peanut-production counties or in our far eastern counties. Damage can occur almost any time during the season and is usually more prevalent during dry conditions and on sandy soils. Mite damage appears as a slight yellow stippling of the leaves, which later changes to a reddish or bronze color. Mite damage also can be recognized by the presence of fine webbing on the undersides of the affected leaves. This webbing, if present on lower leaves, often traps blown sand grains in seedling cotton. In severe infestations, the damage can cause widespread leaf yellowing, followed by bronzing and defoliation, often beginning with lower leaf drop.

Visual spot-checks for mites can be made while scouting for other pests. Initial mite infestations often occur at field borders adjacent to drying corn, weeds, or mowed ditch banks or roadways. With the widespread adoption of strip- and no-till cotton, however, spider mites can sometimes build up throughout cotton fields. Even with obvious yellowing and defoliation, the presence of an active mite population in the field should be confirmed before treating. A hand lens of 10× magnification or greater is indispensable when scouting for these tiny arthropods and their eggs, and in identifying the fungal parasite. In treating for mites, one or two expensive applications with excellent coverage are sometimes required and often provide only fair control. A fungus that preys on mites is often present, particularly under rainy or humid conditions, and may greatly reduce mite numbers while the damage symptoms are still present. Do not spray if rain is likely.

### **Fall Armyworms and Beet Armyworms**

The presence of fall armyworms and their damage is recorded as part of bollworm scouting. Additional samples are usually unnecessary. Damage from fall and beet armyworms is typically low or absent in Bollgard 3, TwinLink Plus, and WideStrike 3 cotton varieties. However, fall armyworms are usually only a sporadic pest of cotton, even in the pre-*Bt* cotton days and should not be a widespread problem on *Bt* cotton. Because fall armyworms migrate into North Carolina from farther south, their numbers vary greatly from year to year and normally reach higher levels in the southern and far eastern counties.

Beet armyworms are rarely cotton pests on North Carolina *Bt* cotton. Although a few are noted on cotton almost every year, they are usually at low levels.

### **Loopers**

Cabbage and soybean loopers rarely damage cotton in North Carolina for several reasons: (1) they prefer foliage, (2) are prone to pathogenic virus attacks (less so with the soybean looper), (3) occur sporadically, and (4) seldom become established on *Bt* cotton varieties. In non-*Bt* cotton, observing foliage during routine late-season scouting for other pests will, in most cases, suffice for looper monitoring.

If significant leaf feeding is seen, the average percentage of defoliation across the entire field should be recorded. As a general rule, if defoliation in cotton exceeds 30% with a significant portion (25% or more) of the bolls still immature and filling out, treatment may be needed.

Soybean loopers are not controlled with pyrethroids. Fortunately, Bollgard 3, TwinLink Plus, and WideStrike 3 cotton varieties provide excellent looper controls.

### **Beneficial Insects**

About a dozen beneficial insects are commonly found in North Carolina cotton: ambush bugs, big-eyed bugs, minute pirate bugs, green lacewings, two species of ladybird beetles, and several types of spiders. They are of two types: (1) predators that prey upon an insect pest; or (2) parasites that live within the host insect. These insects, particularly the predators, reduce the number of eggs and larvae of bollworms and other caterpillars, as well as cotton aphids. Both immature and adult predators can be important biological control agents for cotton pests. Because these allies lessen the impact of pest insects, common sense dictates that producers use them as a management tool. Their presence often means that growers can delay—and, on occasion, eliminate—some insecticide applications, particularly aphid treatments.

Many complex factors are involved in determining just how many of each beneficial insect species are needed to influence a given level of pests. Therefore, it is usually not practical to assess the value of these insects except in a very general way. That is, if relatively high numbers of beneficial insects are consuming a large proportion of aphids or bollworm eggs and larvae, the treatment threshold will be reached later than normal, thus reducing the number of insecticide applications needed. In the case of fungal pathogens attacking spider mites or cotton aphids, finding even small amounts of the pathogen may signal the beginning of an epizootic that often reduces pest levels significantly over a widespread area. By the same token, in cotton, beneficial insects appear to have only a limited impact on stink bugs and plant bugs in most situations.

Presently, the careful observation of sound economic thresholds offers the producer the best odds of balancing numbers of beneficial insect against damaging insects. Cotton aphid infestations are usually best managed by avoiding insecticides and allowing beneficial insects and fungi to limit populations.

## CULTURAL CONTROL OF COTTON INSECTS

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Fortunately, most of our agronomic and weed-management recommendations geared toward providing the cotton crop a fast start, rapid development, and early maturity also aid in the management of late-season insects, particularly bollworms, plant bugs, and stink bugs. Practices that encourage early maturity, such as avoidance of June planting, render the cotton plant less attractive to moths and bugs, and less attractive and susceptible to boll damage. In our fall boll-damage surveys, late rank plants often sustain two to four times the damage of those that mature early. These are a few recommended cultural practices:

1. Match varieties to soil type—Some mid- and late-season varieties can grow excessively large, rank plants, precipitating late-season insect problems; reserve these varieties for earlier planting or sandy soils.
2. Avoid late planting—While employing the earliest planting date possible is not critical (and may result in higher thrips damage), avoidance of late planting (after the fourth week in May) can have a dramatic effect on minimizing late-season insects. This avoidance of late planting is the single-most important cultural factor in reducing late-season insect damage.
3. Adhere to recommended nitrogen levels—High levels of nitrogen, particularly when coupled with late planting and high rainfall levels, can trigger rank cotton growth and high bollworm populations on conventional cotton, and higher stink bug and plant bug levels on *Bt* cottons.
4. Use of PGRs (plant growth regulators)—The use of mepiquat chloride and other similar products on fields with either a history of rank growth or a propensity for fast plant growth will hasten maturity and may facilitate late-season insect control.
5. Reduced tillage—Thrips populations tend to be lower in reduced-till environments. While the exact mechanism is not known, thrips densities are generally highest in conventional till situations. In reduced till, plants also tend to grow taller, and moisture is preserved for the roots. This moisture retention can help plants that may have been stunted by thrips (aboveground stunting also reduces root mass) by allowing roots to access more moisture during critically dry spring conditions.
6. Optimal irrigation—Bollworms lay more eggs in rank irrigated cotton. Therefore, it is important to optimize irrigation to maximize yield, while minimizing excessive irrigation that might place cotton more at risk for bollworm infestation.

## THRESHOLDS

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A threshold is the level of plant damage or the number of insects at which treatment is recommended—that is, the level at which treatment will pay for itself. Threshold numbers are usually expressed in terms of the percentage or number of insects or instances of damage observed per sample (such as a given number of bolls, sweep net samples, or drop cloth samples). Often based on years of research, these thresholds form the basis for sound treatment decisions. Thresholds, however, are only general guidelines applicable to the entire state. A knowledgeable consultant or advisor may be able to modify a threshold, depending on the region

of the state, its history of insect problems, and the amount of risk that the consultant and the farmer are willing to take. Also, these thresholds are refined periodically based on new research. Current thresholds for the important cotton pests are as follows:

### **Thrips**

- On cotton from the cotyledon to the fifth true-leaf stage: An average of two immature thrips per plant, or an average of one immature thrips per plant for each one true leaf.
- Timing of thrips applications, especially following seed treatments, is often best targeted right before the first true-leaf stage.
- Do not treat ThryvOn cotton for thrips.

### **Plant Bugs**

*Prebloom thresholds* are to be used when square retention rate drops below 80%. From initiation of squaring until the first or second week of blooming:

- Eight plant bugs per 100 sweeps.
- The sweep net threshold may be raised to 10 if fruiting begins on nodes four through six or lowered to six to seven if fruiting begins on node eight or higher. Thresholds also may be somewhat lowered in stressed cotton.
- Use the same threshold for ThryvOn cotton.

### *Postbloom thresholds*

- 0 to 6% dirty blooms—No additional scouting for plant bugs is indicated for five to seven days. Count any brown anthers as damaged. This “threshold” should be used along with other assessments, if indicated. Higher dirty bloom levels indicate need for additional assessments (with a ground cloth).
- 10 to 50% initial internal damage to quarter-sized bolls based on week of bloom, as part of stink bug sampling (Figures 12-1 and 12-2).
- Two to three adult and medium-to-large nymphs per 5 row-feet with a black beat cloth (ground cloth). (Sweep net thresholds for plant bugs in postbloom cotton typically underestimate the levels of immature plant bugs.)
- Use the same threshold for ThryvOn and non-ThryvOn cotton.

### **Spider Mites**

- General leaf discoloration (chlorosis, bronzing, or both), plus live mites over most of the field and defoliation from mites in 25% or more of the field. (If rain is imminent, delay treatment and reevaluate three to four days after the rain. If a miticide is used, two applications are sometimes necessary.)

### **Stink Bugs**

Damaged Bolls (dynamic threshold)

- 10 to 50% internal stink bug damage to quarter-sized bolls (see Table 12-1). The higher thresholds are used during the first two weeks of blooming or later in the season to reflect

advancing boll maturity (see Table 12-2 and Figure 12-1). The lower 10% threshold is advised during weeks three to five of blooming. Yield losses resulting from stink bug damage are less likely during the initial two and final weeks of blooming.

Beat Cloth (shake cloth; black) and Sweep Net (15-inch diameter)

- *These devices should only be used to confirm the presence of green versus brown stink bugs and are thus no longer employed to determine if threshold levels are present.*

## **Non-Bt Cotton**

### **Bollworms and Tobacco Budworms**

*Prebloom (with Bollgard 3, TwinLink Plus, and WideStrike 3 cotton, early season June damage from bollworm and tobacco budworms is essentially nonexistent).* On the few remaining acres of conventional cotton, limit possible treatment to one well-timed application of a non-pyrethroid, such as Blackhawk, Vantacor, Steward, or Denim. Vantacor is the superior insecticide. Treatment before bloom seldom pays, however.

- 15 bollworms per 100 terminals  
or
- Eight bollworms per 100 squares

*Postbloom Egg Threshold (after the onset of the major bollworm moth flight):*

- 10 or more eggs per 100 terminals  
or
- Two to three eggs per 100 fruiting forms

*Postbloom Larval Threshold (usually after the egg threshold has been employed, but also after blooming begins and before major bollworm flight, particularly if tobacco budworms are present):*

- Three live worms per 100 fruit (squares, blooms, or bolls)

### **Bt Cotton (used against the major bollworm generations)**

- 4% damaged bolls

### **Fall Armyworms (non-Bt cotton)**

Same as the postbloom larval threshold for bollworm but may be revised upward late in the season (after September 1). The fall armyworm is primarily a late-season cotton pest. Pay particular attention to the small, grayish, fuzzy egg masses deposited on the undersides of leaves, and to “window paning” in the bracts of lower bolls and blooms for the presence of larvae. Correct identification is critical; many bollworm insecticides are ineffective against fall armyworms.

### ***European Corn Borers (non-Bt cotton)***

Use of the old bollworm egg threshold (10% eggs in terminals, or 2 to 3% down in the canopy, or on blooms) will often control much of the late ECB generation on conventional cotton. *Bt* cotton lines are seldom damaged. Follow the more detailed guidelines in ENT-COT-6, *Cotton Insect Scouting Guide*, at [cotton.ces.ncsu.edu/insect-scouting-guide](http://cotton.ces.ncsu.edu/insect-scouting-guide).

### ***Cabbage and Soybean Loopers (non-Bt cotton)***

- 30 to 35% defoliation and presence of more than 25% immature bolls

### ***Beet Armyworms (non-Bt cotton)***

- 10% live beet armyworms in squares, blooms, or small bolls in blooming cotton  
or
- 10 beet armyworms per foot of row later in the season (when squares and blooms will not produce harvestable bolls)  
or
- 15% of blooms with one or more live larvae

### ***Cotton Aphids***

- Using the Aphid Rating Scale, treat at a rating of 4 in opening cotton (15% open bolls or greater) or at a rating of 5 in pre-opening cotton if plants are under stress or stunted and if aphid mummies and fungi are at low levels. Treatment is discouraged under most circumstances because of its deleterious effect on beneficial predators and parasites that attack aphid populations. In opening cotton, treat only if plants are heavily infested and honeydew is detected in significant portions of the field.
- The Aphid Rating Scale may help define situations where treatment may be indicated.

## **RECOMMENDATIONS**

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A complete listing of recommended insecticides for use in controlling cotton insects may be found in the *North Carolina Agricultural Chemicals Manual* ([content.ces.ncsu.edu/north-carolina-agricultural-chemicals-manual](http://content.ces.ncsu.edu/north-carolina-agricultural-chemicals-manual)).

## NOTES

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