2012
GEORGIA COTTON PRODUCTION GUIDE

COOPERATIVE EXTENSION / THE UNIVERSITY OF GEORGIA
COLLEGE OF AGRICULTURAL AND ENVIRONMENTAL SCIENCES

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THE 2011 CROP YEAR IN REVIEW

The 2011 production season was certainly unique and quite different from that of 2010. Cotton acreage increased approximately 15 % from 2010, with an estimated 1,520,000 acres harvested in Georgia during 2011, according to the National Agricultural Statistics Service. Most of the cotton crop this year was planted relatively on time, although the hot dry spring weather conditions resulted in poor stands in some dryland fields, necessitating replanting for many of these dryland fields. As a result, some dryland fields developed somewhat later than normal. The 2011 planting season may have been one of the hottest and driest on record, causing significant stand establishment problems, even in a few irrigated fields with larger pivots that were slow to turn around. Rains returned across most of the state near the end of June, leading into July when earlier planted fields began blooming. The month of July was relatively wet, allowing much of the earlier planted irrigated crop to develop a very large boll load with excellent yield potential. Rains began to subside across the state during August, rewarding the early planted irrigated crop in terms of reducing boll rot or hard lock issues which are often observed when rains are frequent in August. However, many of the later planted dryland fields began blooming around or near the first of August and the dry August weather may have penalized yield potential in some of these situations. There were also several reports of growers encountering difficulty defoliating which may have also resulted from the August weather conditioning the crop for poor defoliation. The remainder of the fall brought about sporadic rains and some periods of cool temperatures, allowing for more effective defoliation and somewhat decent harvest conditions. Although yields were highly variable depending upon rainfall, the average state yield was estimated at 837 lbs/acre as of December 1st, 2011, which isn't bad considering the spring weather. Average statewide yields continue to remain above 800 lbs/acre, despite the loss of DP 555 BR, which is a true testament to Georgia's growers, their commitment to cotton, and the release of superior varieties.

The 2011 season was the first season in several years that DP 555 BR was not planted, finalizing the transition to 2-gene Bt technologies. Now that other factors tend to drive variety selection in particular situations, -and- since a single replacement for DP 555 BG/RR was unlikely, growers began to plant a wider array of varieties in 2011. The 2011 cotton acreage in Georgia was predominately comprised of Deltapine varieties (59.2%), FiberMax varieties (11.7%), and Phytogen varieties (25.2%) (http://www.ams.usda.gov/AMSv1.0/). Herbicide resistant Palmer amaranth (pigweed) continued to be a serious production challenge across much of the state, and was the driving force behind variety selection in many areas.

Quality of the 2011 crop was noticeably better than previous years for some parameters. Of bales classed as of December 8, 2011, 2.8 percent were short staple (<34) and 8.8 percent were high mic (>4.9). Staple was higher and micronaire was lower than in 2010, likely due to the wetter weather during July and fiber characteristics of newer varieties. Fiber length uniformity continues to improve compared to previous years, also a likely result of the changes in varieties.

Fiber Quality of Bales Classed at the Macon USDA Classing Office, 2008-2011

	Color Grade 31/41 or better (% of crop)	Bark/ Grass/ Prep (% of crop)	Staple (32nds)	Strength (g/tex)	Mic	Uniformity
2008	25 / 93	all < 1.0	34.4	28.7	46	80.2
2009	26 / 96	all < 1.0	35	28.8	45	80.3
2010	50 / 90	all < 1.0	35	29.9	48	81
2011	38 / 84	2.6 / <1 / 1	36	29.6	46	81.7
Bales classed short staple (< 34) and high mic (>4.9) 2008: 20% and 21% 2009: 22% and 20% 2010: 4% and 9% 2011: 2.8% and 8.8% Fiber quality data as of December 8, 2011. Source: http://www.ams.usda.gov/AMSv1.0/						

COTTON ECONOMIC OUTLOOK FOR 2012

Cotton prices have been very good for the past 2 crop seasons. Futures prices for the 2010 crop reached $2.00 per pound. Prices for the 2011 crop have thus far reached as high as $1.40 per pound. Historically, even $1.00 cotton is almost unheard of.

Despite high prices, marketing decisions have been frustrating. Many producers did not benefit from these high prices. For the 2010 crop, prices prior to and through harvest ranged from the low 70's to around $1.50 per pound. Prices were not expected to be over $1.00, so producers contacted most of their cotton at around $1.00 or less before prices began to increase. After harvest, prices increased to the $2.00 level but by that time most cotton had been sold.

For the 2011 crop, prices have ranged from around 90 cents to around $1.40. Producers contracted a reasonable portion of their expected production during the winter and spring of 2011 prior to planting when prices were often well over $1.00. The early summer drought then resulted in poor emergence and some acreage having to be replanted. Producers became concerned about being able to deliver on bale contracts and some decided to buy-out the contracts. Later in the summer when production potential was better known, prices had begun to trend down and pricing opportunities had dwindled.

Prices are weaker but still attractive for the 2012 crop. Futures prices have thus far ranged more narrowly from around $1.05 to the high 80's. Some 2012 cotton may already be priced (contracted) at around 95 cents to $1.00. The key factors in the 2012 price outlook will include US acreage and production in 2012, World demand (which has been weak for 2011), and World supplies (which are now much less "tight" than for the 2010 and 2011 crops).

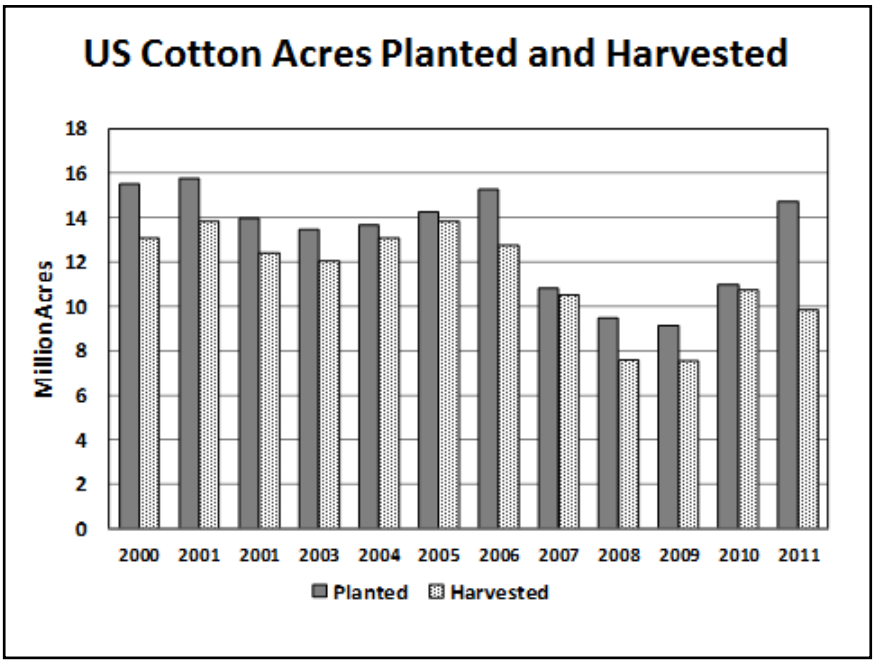
US Acreage and Production

After 3 consecutive years of decline from 2007-2009 due to high corn and soybean prices and competitive net returns, US cotton acreage began to rebound in 2010 and then significantly more in 2011. US producers planted 14.72 million acres of cotton last season compared to only 10.97 million in 2010. Due primarily to severe drought in Texas, US acreage abandonment was record

high at 33% and acreage harvested only 1.15 million acres more than in 2010.

The US crop is forecast at 16.3 million bales. Given the acres planted, if yield and acreage abandonment had been closer to normal, the crop could have been 21 to 22 million bales. Poor crop conditions and production uncertainty were major factors holding 2011 crop prices at even the $1.00 level. Had the US crop been nearer its full potential, it could easily have trimmed another 10 to 15 cents off the market.

This is an important consideration looking ahead to 2012. Assuming a good average yield and assuming normal abandonment, the US could have produced this year's crop (16.3 million bales) with roughly only 11 million acres planted—3.72 million less than was actually planted or roughly the same acreage as in 2010.



Assuming that 2012 is a "normal" year, US cotton production would increase in 2012 unless acreage planted is reduced by almost 4 million acres. There is a general belief that US cotton acreage may decline in 2012 but not to this extent. US cotton production, therefore, would increase in 2012 even with an acreage reduction. Considering the weakness in Demand, this may not bode well for prices.

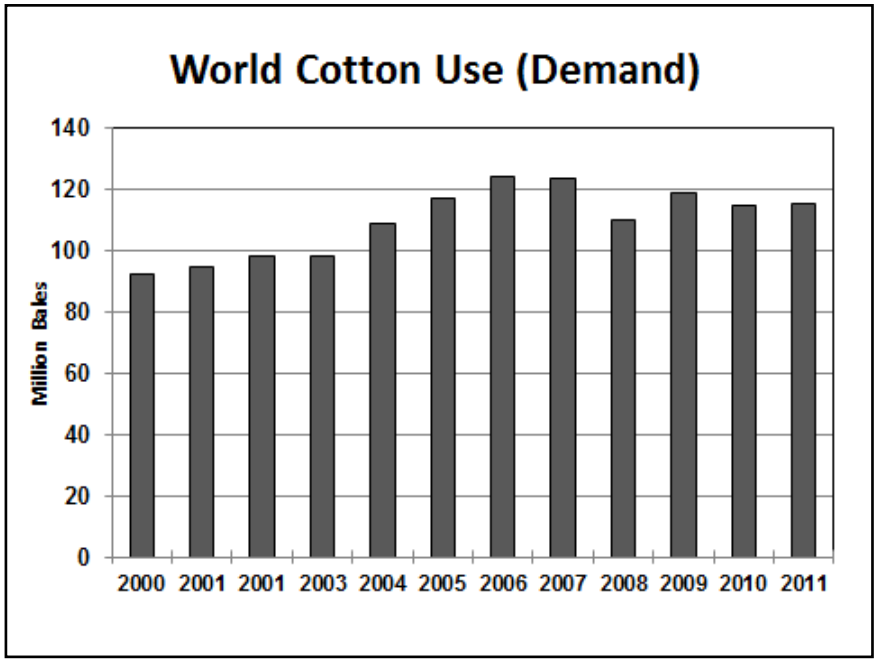
World Demand

World use of cotton in US and foreign textile mills has declined and flattened since the peak years of 2006 and 2007. This is due to global economic slowdown and uncertainty, high cotton prices especially for the 2010 crop, and competition from man-made fibers.

World Demand for the 2011 crop year is forecast at 114.27 million bales. This most recent projection is approximately 5 million bales less than earlier forecasts as demand has softened.

Demand growth for the remainder of the 2011 crop marketing year and the 2012 crop is expected to be slow. If US production increases in 2012, continued stagnant demand could create further downward pressure on price but foreign production will also be important. Several key foreign

countries like China, India, and Pakistan experienced increased production in 2011. If foreign production declines, this could offset an increase in the US.



China is the #1 user and importer of cotton in the World. China is expected to import 2 million bales more cotton during the 2011 crop marketing year than for 2010 but indications are that such purchases are being made, in part, to help rebuild low stocks and not for mill use. Building stocks now from the 2011 crop could be positioning supplies for the 2012 pipeline. This could possibly mean a reduced need for imports of the 2012 crop unless demand improves.

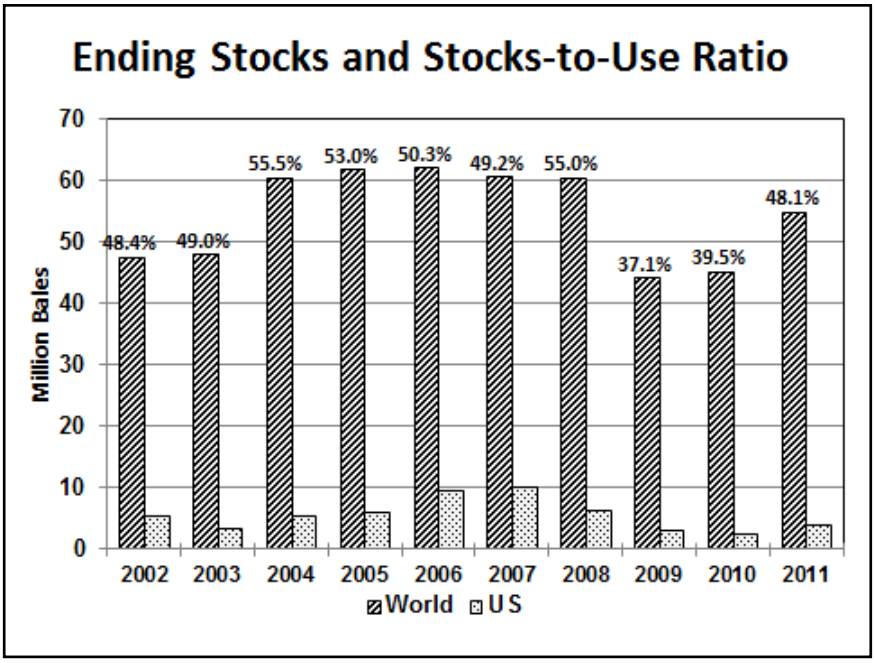
Supply and Stocks

The US had a short crop in 2011 but it was still 1 million bales more than many thought possible given the horror stories coming out of Texas. Foreign production increased 11% in 2011 from 2010. Increased foreign production combined with flat demand has resulted in a much less tight World supply/demand picture than in 2010 and 2011.

By the end of the 2011 crop marketing year, remaining inventories (Ending Stocks) of cotton are projected to be 55 million bales—up roughly 10 million bales from the low 2009 and 2010 levels. The stocks-to-use ratio is projected to improve from less than 40% to almost 50%.

Prices for the 2010 crop were high, in part, because we entered the year (from 2009) with very low stocks. For the 2011 crop, prices has also been high due to low stocks (from the 2010 crop) but tempered somewhat by increased foreign production and stagnant demand.

The tight supply and stocks situation of the past 2 seasons seems to have eased significantly. It is only one factor but prices tend to move inversely to the stocks-to-use ratio-- if stocks-to-use increases, price tend to decrease and vise-versa. 2012 production greater than demand will continue to build stocks and keep a lid on prices. If demand improves, depending on production, stocks-to-use could remain stable or even tighten some.



2012 Price Outlook

The days of $1.50 to $2.00 cotton may be over. Production and supply have increased and demand has weakened. Looking ahead for the 2012 crop, the real question is whether or not the days of $1.00 cotton are also over.

US cotton production in 2012 is likely to be near or above 2011. Even if acreage is reduced or stays about the same as 2011, more normal abandonment would keep production up. US cotton production in 2012 will likely be above 2011. Foreign production is more unknown.

Demand has been weak and the stocks-to-use ratio has eased. Assuming US and World production about the same or higher in 2012, this scenario would not set the stage for continued high prices. On the other hand, if US and World production is down and/or if demand improves, prices could remain near or even above current levels.

The most likely optimistic price outlook for 2012 would be $0.90 to $1.15 per pound. The most likely pessimistic outlook would be $0.70 to $0.85 per pound. Currently, Dec12 cotton futures are in the upper 80's to low 90's. Prices cannot fall too far in relation to corn and peanuts otherwise even more acreage is likely to shift out of cotton.

Prices could still rally based on growing conditions as we approach the 2012 planting season and over the summer. Taking some early price protection but a flexible marketing plan that also allows producers to take advantage of better opportunities later, should that happen, would seem to be a good strategy. Prices will continue to be very volatile. Although most signs seem to point to weaker prices compared to 2010 and 2011, improvement can still be expected if 2011 crop remaining export sales are strong, if demand shows improvement for 2012, and if US and/or Foreign production for 2012 becomes questionable.

Net Returns and Georgia Cotton in 2012

Georgia farmers planted 1.6 million acres of cotton in 2011—a new modern record surpassing 1.5 million acres in 1995 and again in 2000. The state average yield for 2011is forecast at 837

pounds per acre which, if achieved, would be remarkable given the drought and other challenges during the season.

How much cotton under normal circumstances would actually have been planted in 2011 is unknown. Some acreage was replanted (some twice) and some producers planted extra acres late to make sure they could deliver on bale contracts.
Cotton acreage could be down in 2012. Strong competition is expected from peanuts and, to a lesser extent, corn. Much will depend on contract prices for peanuts and the availability of contracts. Peanut acreage will increase but the increase will be controlled.

The following are preliminary/early estimates of comparative net returns for 2012. These estimates are based on the yields and costs shown and crop prices as of early December 2011 and expectations for season average prices.

At the price shown, peanuts offer the highest expected net return. Peanuts around $575/ton would offer approximately the same net return as 87½ cent cotton. At $700/ton for peanuts, cotton at $1.10 would be needed to provide equal net return.

Peanut acreage may be determined by contract price and poundage available. At the price shown, peanuts under contract are attractive. The harder acreage decision will be cotton vs. corn vs. peanuts over the contract at an unknown price.

Preliminary Estimates of 2012 Georgia Crop Per Acre Net Returns, Non-Irrigated[1]

	Corn	Cotton	Gr. Sorg.	Peanuts	Soybeans
Expected Yield	85	700	65	2,900	30
Expected Price	$6.25	$0.875	$5.88	$700	$11.00
Expected Revenue	$531	$613	$382	$1,015	$330
Variable Costs	$322	$442	$240	$639	$262
Net Return Per Acre	**$210**	**$171**	**$143**	**$376**	**$69**

1/ Average of conventional and strip-till production.

Preliminary Estimates of 2012 Georgia Crop Per Acre Net Returns, Irrigated[1]

	Corn	Cotton	Gr. Sorg.	Peanuts	Soybeans
Expected Yield	185	1,200	100	4,200	60
Expected Price	$6.25	$0.875	$5.88	$700	$11.00
Expected Revenue	$1,156	$1,050	$588	$1,470	$660
Variable Costs	$633	$577	$331	$750	$358
Net Return Per Acre	**$524**	**$473**	**$258**	**$721**	**$302**

1/ Average of conventional and strip-till production.

FERTILIZATION

Lime

The official UGA recommendation or "target" pH (water) for cotton is 6.0. However, a field with an average pH of 6.0 may very well have large areas measuring below this target pH. Recent precision soil sampling techniques have indicated that this happens frequently. Therefore, growers using standard soil sampling techniques are encouraged to maintain their soil pH for cotton between 6.0 and 6.3. Liming to pH values above 6.3 may cause manganese deficiency problems in the Flatwoods soil region. However, this problem can be handled easily with applications of foliar Mn during the growing season. Liming soils 6.0 to 6.3 for all soil regions in Georgia is critical for proper uptake and utilization of nutrients that are essential for plant growth. Fertilizer use efficiency is also best in this range. In addition, toxic elements such as aluminum (Al) are kept unavailable when pH is above 5.5.

There are many factors that affect the soil pH reading obtained from soil testing. Possible reasons for seeing abrupt changes in soil pH include 1) sampling variability (spatial and depth), 2) rainfall amounts and 3) nitrogen fertilizer usage. Even so, changes of more than 0.5 in soil pH in one year should be considered suspect and called for resampling.

Dolomitic lime (that has 6 % or more Mg) is still the most common liming material used on Georgia cotton and provides magnesium (Mg) as well as calcium (Ca) and a pH adjustment. Calcitic lime (less than 6% Mg) is becoming more popular and may be used in cases where high soil Mg levels occur. **If calcitic lime is used for consecutive years, soil test Mg levels should be tracked closely with soil testing.** As soon as soil test Mg levels start to drop out of the high range into the medium range, the use of dolomitic lime should be resumed. The reason for this is that dolomitic lime is the most economical source of Mg fertilizer. In addition, a good liming program should supply all the Ca that a cotton plant needs for high yields and quality. Calcium deficiency in cotton is very rare, and the need for foliar Ca applications or small doses of supplemental Ca applied to soil should be considered unnecessary.

Phosphorous and Potassium

Phosphorous (P) and potassium (K) levels in soil should be maintained in the upper medium range as determined by soil testing. All of the P requirements should be applied preplant since it is relatively immobile in soil and is important to seedling growth. All of the K requirements should also be applied preplant on all soil types including Piedmont, Coastal Plain, and Deep Sand soils. Widespread K uptake and deficiency problems occurred again on the 2010 crop (like in 2008 and 2009). This problem is also made evident by weak areas in the fields (usually in sandy washed out areas) and the presence of certain leafspots. Cercospora, Alternaria and Stemphylium leafspot have all been linked to potassium deficiency. These leafspot diseases are considered secondary to potassium deficiency and if potassium deficiency is avoided then these leafspots should be prevented. **The relatively new Corynespora leafspot , however, does not appear to be linked to potassium deficiency.**

Split applications of K, especially half the recommended rate at planting and half at sidedress, have also not proven to be effective on Tifton type soils. In fact, in some cases this approach may lead to potassium deficiency before sidedress applications are made. Recent field trials conducted in Georgia have focused on additional soil-applied K during N sidedressing versus foliar K applications during peak bloom (first 4 weeks of bloom). Preliminary results from studies conducted on Coastal Plain soils indicate that foliar K may be more effective than sidedress K in

improving yields. Research on Deep Sands is still needed to determine which approach is more effective. **Currently, foliar K applications should automatically be considered on deep sands (more than 18 inches to subsoil clay), low K soils, high Mg soils, high-yielding conditions, short season varieties and especially, where severe K deficiencies and leafspot have been observed in the past.** Two foliar applications of 5-10 lbs/K2O in each application during early bloom (first thru 4th week of bloom) should be considered in these situations.

Newer cotton varieties are very likely to be faster fruiting and earlier in maturity compared to DP 555 B/R. This makes them more susceptible to K deficiency. In most situations, **the best strategy to avoid K deficiency is to 1) soil test, 2) apply the recommended K fertilizer at planting, and 3) consider foliar feeding K during peak bloom**.

Currently, there are a number of commercially available fertilizer additives that are designed to improve the uptake efficiency of P and K fertilizers. Research results with Georgia cotton showing consistent advantages to these materials have not been seen at this time and their widespread adoption is not recommended.

Nitrogen Management

Nitrogen is probably the most important fertilizer used on cotton, yet it is the most difficult to manage. Low N rates can reduce yield and quality while excessive N rates can cause rank growth, boll rot, delayed maturity, difficult defoliation, and poor quality and yield. Total N rates for cotton should be based on soil type, previous crop, growth history, and yield potential. Base N rates recommended by the UGA Soil Testing Lab according to yield goals are listed below.

Yield Goal (lb lint/A)	Recommended N Rate (lb N/A)
750	60
1000	75
1250	90
1500	105

These N rates should then be adjusted according to other factors. For example:

Increase N rate by 25% if:	Decrease N rate by 25% if:
Deep sandy soil	Cotton following peanuts or soybeans
Cotton following cotton	Cotton following good stands of winter legumes such as clover or vetch
History of inadequate stalk growth	History of rank or excessive vegetative growth

Yield goals should always be realistic, preferably based on past production records. For N rates above 100 lb/A, cotton should be highly managed in terms of insect control, plant height, and boron fertilization. Total N rates above 120 lb/A should only be needed on deep sands or in special cases of history of inadequate stalk growth or where excessive leaching has occurred. The N rates for the 1250 and 1500 lb lint/A yield goals assume irrigation.

The total N rate should always be applied in split applications. Apply 1/4 to 1/3 of the recommended N at planting and the remainder at sidedress. The preplant or at planting N application is critical for getting the crop off to a good start and ensuring adequate N nutrition prior to side-dressing. **Sidedress N between first square and first bloom** depending on growth

and color (toward first square if slow growing and pale green, toward first bloom if rapid growth and dark green). A portion of the sidedress N can also be applied as foliar treatments or through irrigation systems.

There are a number of sidedress nitrogen fertilizer materials that can be used on cotton including liquid UAN solutions, ammonium nitrate and urea. UAN solutions are made up of urea and ammonium nitrate and often contain sulfur (e.g. 28-0-0-5). Ammonium nitrate is losing favor as a sidedress N source for cotton due to higher cost and burn potential. Urea is considered an alternative to ammonium nitrate but is known to be prone to volatilization losses. Volatilization losses can be minimized however by irrigating after a urea application or by use of a urease inhibitor such as Agrotain. Another liquid N solution that is gaining popularity as a sidedress N source for cotton is "19 %" or 18-0-0-3(S). These sources are derived from a by-product of the Attapulgite clay mining industry in southwest Georgia and are made up approximately 60 % nitrate and 40 % ammonium (no urea). Replicated, small plot research trials conducted in 2010 and 2011 indicate that 18-0-0-3(S) is comparable to 28-0-0-5(S) in terms of producing cotton yield. Feed grade urea is still the product of choice for foliar N applications later in the growing season. Controlled release nitrogen foliar products are also available but usually contain potassium and boron and are less concentrated in N.

Sulfur

The official UGA fertilizer recommendation for sulfur is 10 lb/A. Sulfur can be applied either with preplant fertilizer or with sidedress N materials such as 28-0-0-5 or ammonium sulfate. Sulfur fertilization is most important on sandy, low organic matter Coastal Plain soils. With less S input from cleaned ("scrubbed") power plant smokestack emissions and the recent trend toward high-analysis (S-free) fertilizers, including S in a cotton fertilizer program is currently very critical. Adequate S fertilization is also important where higher rates of fertilizer N are used. Since S deficiency symptoms are similar to N deficiency (yellowing) and the N:S ratio in plant tissue is a good indicator of S nutrition, a plant tissue sample greatly aids in diagnosis when low S is suspected.

Boron

Boron (B) is an essential micronutrient that is important to flowering, pollination, and fruiting of the cotton plant. The standard UGA recommendation of 0.5 lb B/A, applied in two 0.25 lb/A foliar applications between first square and first bloom, fulfills the base requirement for B. Single applications of 0.5 lb B/A can be used but include a greater risk of foliar burn. Foliar applications above the base recommendation of 0.5 lb B/a and up to 2 lb B/A (applied in increments of no greater than 0.5 lb B/A per application) may help move nitrogen and carbohydrates from leaves into developing fruit. Cumulative applications totaling above 2 lb B/A, however, may reduce yields and quality. The need for additional B above the 0.5 lb/A rate is best determined by tissue or petiole testing. Since B leaches readily through sandy soils, foliar applications have always been considered the most effective and efficient application method. However, on a typical Coastal Plain soil like the Tifton series, with normal rainfall and irrigation, preplant, starter, and sidedress soil applications are also be considered effective. If no B is included in preplant, starter, or sidedress soil-applied fertilizer applications, is foliar B alone (with no insecticide or growth regulator) worth the trip? Yes, especially on sandier soils and with irrigation or adequate rainfall.

Numerous B fertilizer materials are currently available. Most are either derived from boric acid or sodium borate and can be either in the liquid or wettable powder form. There are many "additives" used with these base B materials such as nitrogen and complexing agents designed to

improve efficiency of uptake. However, extensive field testing over recent years has proven that all of the B fertilizers currently on the market are equally effective in terms of plant nutrition. Therefore, choice of B fertilizers should be made on price per pound of B.

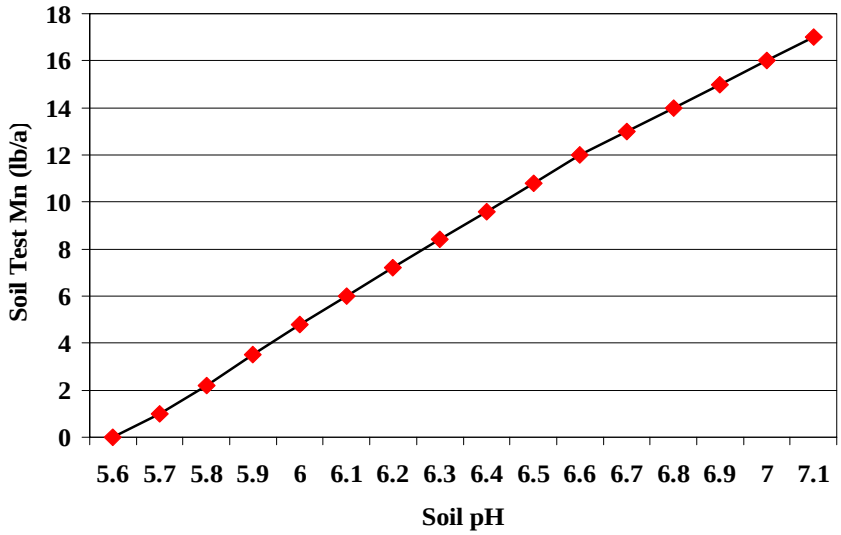
In addition, at least one boron fertilizer currently sold in Georgia is recommended at application rates well below the recommended 0.5 lb B/A rate- in fact the labeled rate only provides 0.025 lb B/A !. **As far as fulfilling the base recommendation for B, any boron fertilizer recommended at a rate that does not provide at least 0.25 lb B/a should be considered uneconomical !**

Manganese and Zinc

Manganese (Mn) and zinc (Zn) are two essential micronutrients that are routinely measured in soil testing at UGA and can sometimes be deficient in cotton. Both Mn and Zn are less available for plant uptake at higher soil pHs. Therefore, soil test results should be examined closely for the combination of low levels of Mn or Zn and high soil pH.

In order to minimize the chance of Mn deficiency on cotton, minimum levels of soil test manganese should be maintained with varying pH levels as shown in Figure 1 below.

Figure 1. Relationship between pH and manganese availability. Maintain soil test manganese levels above the line to help avoid manganese deficiency. Source: Soil Test Handbook for Georgia



Notice on the graph, that if soil pH is at the recommended target of 6.0, soil test level of Mn should be at least 5 lb/A. At soil pH of 6.5 the soil test level of Mn should be at least 11 lb/A.

Even when the soil test level of Mn falls below the recommended level for a given pH, the result is not an automatic recommendation to apply Mn fertilizer. Instead, the crop should be monitored using tissue testing between first square and first bloom and foliar Mn can be applied if a deficiency is confirmed. Small amounts of Mn can also be added to starter fertilizer applications. Be sure to read and apply Mn and other micronutrients starter packages according to label to avoid burn and stand loss.

Large amounts of soil applied Mn (above 5 lb/A) are not considered to be economical. Therefore, in situations where soil test levels of Mn need to be built up, do so slowly and monitor the crop for deficiency using tissue testing. In essence, if a grower likes to maintain soil pH near the UGA target pH of 6.0, then soil test Mn should be built to and maintained around 5 lb Mn/A. If the grower likes to maintain soil pH at a higher level, say around 6.5, then the soil test level of Mn needs to be built to and maintained around 11 lb/A.

Cotton growers in the Flatwoods soil region are cautioned not to maintain soil pH above 6.3 to minimize the chance of Mn deficiency (peanuts are also susceptible to Mn deficiency at this pH on these soils). If soil pH is maintained above 6.3 on these soils, tissue testing is recommended regardless of soil test Mn levels in order to avoid deficiencies. If a deficiency is detected in this situation, it can be corrected by foliar feeding Mn.

Soil test levels of zinc should be maintained between 2 and 8 lb/A. Unlike Mn, if soil test Zn falls below this range, it is considered low and an application of zinc fertilizer will be recommended. The recommended Zn fertilizer can be applied with broadcast preplant fertilizer or more efficiently, with a starter fertilizer application. In the event that no zinc is applied to the soil even though recommended by soil testing, a foliar application of zinc can be made. Tissue testing in both cases, whether Zn was applied to soil or applied foliar, is recommended. The tissue sample should be taken between first square and first bloom. Tissue sampling at first square is better than at first bloom in order to correct the deficiency before the crop experiences any possible reduction in yield.

Deficiencies of the other essential micronutrients including copper, iron, chlorine, and molybdenum in cotton are extremely rare.

Petiole and Tissue Testing

The University of Georgia currently offers a 10-week petiole testing program for monitoring the N and K status and for making N, K, and B foliar applications. Leaf stems (petioles) are sampled weekly from the same field starting the week before first bloom and analyzed for N, P, and K. Depending on the relationship between N and P, along with other information such as soil moisture and fruit load, foliar N and/or B will be recommended. Potassium levels are also monitored and in the case of K deficiency, soil-applied or foliar K applications will be recommended. A valuable feature of petiole testing programs is that weekly sampling tracks nutrient level trends and allows the detection of deficiencies or excesses up to 2 weeks in advance. Most importantly, petiole testing allows in-season correction of problems. Unfortunately, due to cost and labor, petiole testing is a severely under used tool.

Tissue testing (the leaf blade without the petiole) is also available through the University of Georgia lab and can be especially helpful to detect deficiencies of nutrients not included in petiole testing. Tissue testing is used differently than petiole testing in that it does not track nutrient level trends, but instead gauges nutrient levels in the leaf blade at certain growth stages. Magnesium, S, Mn, and Zn can all be measured and deficiencies can be detected and corrected. The most common growth stage when cotton leaf tissue is sampled is early bloom, the same time as the first petiole sampling. However, tissue sampling can be helpful earlier during the “vegetative” stage to detect and correct early nutrient problems. Tissue sampling can also be used any time during the growing season when trouble shooting if samples are taken from both normal ("good") and affected ("bad") areas of a field.

Since petiole and tissue samples tell different things, it is recommended that both are taken during troubleshooting (especially when past the first bloom stage). For example, petiole samples appear to be a better indicator for N and K deficiency than tissue samples when troubleshooting, but tissue samples are useful for detecting S deficiency (based on the N:S ratio) and micronutrient deficiencies. Also, petiole samples analyzed as tissue samples and vice versa will result in useless information. For example, measuring the nitrate level in a tissue sample or total N in a petiole cannot be interpreted since no data are available for these measurements.

Private labs in the state also offer petiole testing programs and tissue testing services. In recent years, reduced-frequency petiole sampling programs (3 or 6 weeks) and combination packages (petiole and tissue tests) have been offered by private labs. These programs (for example, sampling at the vegetative, early bloom, and late bloom stages) can be attractive due to less sampling and the opportunity to automatically check on secondary and micronutrients with an early tissue test. Timing is even more important with the less-frequently sampled programs since results are based on critical stages of nutrient demand by the cotton plant.

Consistent soil moisture increases the reliability of petiole testing results. Representative samples are more critical for petiole testing than with soil testing. Growers and scouts are urged to closely follow sampling instructions and to provide exact information requested for each sample. Apart from good sampling techniques and consistent soil moisture, petiole results can be unreliable and confusing.

Foliar Fertilization

Foliar fertilization of cotton should be used to supplement a good soil-applied fertilizer program. The most likely nutrients needed for foliar applications are N, B, and K. Foliar N applications can be made as part of an overall N management strategy or as determined by petiole testing. Urea is the most reliable, economical, and proven foliar N material. The standard recommendation is for 4.5 lb N/A as urea in 5 gal or more of water (5gal/A assumes aerial application). Both liquid (23 % N) and granular urea (46 % N dissolved into water) can be used. Applying all the recommended K to soil preplant or at-planting should provide sufficient K for Georgia cotton in most cases**. Again, due to recent leafspot outbreaks caused by K deficiency, foliar K applications should be considered on deep sands (more than 18 inches to subsoil clay), low K soils, high Mg soils, high-yielding or short season varieties, or any fields where K deficiencies and leafspot outbreaks have occurred in the past.** Potassium nitrate is the most common material used for foliar K applications. The standard recommendation is for 4.4 lb K_2O /A in 5 gal or more of water. Again, 5 gal/A assumes aerial application and both liquid and granular KNO_3 can be used. If potassium nitrate is not available, there are other foliar K fertilizers available (for example, liquid 5-0-20) that can also be used to foliar feed K. However, many of these materials do not contain as much K and cannot be applied at rates comparable to potassium nitrate without causing significant leaf burn.

Starter Fertilizers

Although starter fertilizers do not consistently increase cotton yields, they are an effective way of providing early N and P as part of an overall fertility program. Yield responses have been most consistent where soil P levels are low or when planting in cool, wet soils. The use of starter fertilizer is strongly encouraged for conservation tillage systems and in high yield situations. Even though yield responses may not be realized, other advantages include the development of

strong root systems and the encouragement of early rapid growth for weed control with directed herbicide sprays.

Ten gal/A of 10-34-0 is probably the most common starter fertilizer treatment used on Georgia cotton. Nitrogen solutions (with or without S) and complete (N-P-K with micronutrients) dry fertilizer materials can also give good results. Recent research conducted in Georgia showed that the choice of starter fertilizer should depend on soil type and conditions. For example, on "red dirt" such as the Greenville series that has a high affinity for P, P-containing materials such as 10-34-0 should be used. On "stiffer" Coastal Plain soils such as the Tifton series that have medium to high soil test P, N-only materials such as 32 % N liquid can be used. On sandy Coastal Plain soils with histories of S problems, N+S materials such as 28-0-0-5S should be considered. An economic evaluation of this same research showed that in 23 out of 30 comparisons, starter fertilizer gave greater economic returns compared to the untreated check. Adding liquid micronutrient packages to liquid starter materials is also gaining in popularity. This may be a good way of providing recommended B, Zn, and Mn in an overall fertilization program.

The recommended placement for any starter fertilizer is 2 inches below and 2 inches to the side of the row (also referred to as "2-by-2"). **No starter fertilizer materials should be placed in direct contact with the seed in the furrow**. "Dribbling" liquid starter fertilizers on the soil surface, 2 inches to the side of the furrow (to avoid possible leaching into the seed zone) has proven effective on sandy soils but does not work on "stiffer" soils. **Avoid using starter fertilizer rates greater than 15 lb N/A**, even in the 2-by-2 placement, in order to reduce the risk of "starter burn." Under certain conditions -- namely dry, sandy soil -- even 15 lb N/A can burn cotton seedlings if not placed properly.

Starter fertilizers can also be applied in conjunction with herbicide applications by spraying narrow bands (3 to 4 inches) directly over the row behind the press wheel. Mixing liquids containing both N and P with preemergence herbicides can result in clogging of spray nozzles and can decrease the fertilizer effect (or benefit) by spreading the material in a wider band. However, this may supply some needed N when no other preplant N has been applied. Rates should not exceed 20 lb N/A when this method is used.

Poultry Litter

Managed properly, poultry litter (manure mixed with wood shavings) can be a valuable source of plant nutrients for Georgia cotton. The fertilizer value of poultry litter varies depending on a number of factors including moisture, temperature, feed rations, number of batches before clean-out, storage, and handling. However, broiler litter has an approximate analysis equivalent to 3-3-2 (%N – % P_2O - % K_2O). Based on this average, one ton of broiler litter contains 60 lb/A of N, 60 lb/A of P_2O and 40 lb/A of K_2O. Based on record-high fertilizer prices for N, P, and K in 2008, poultry litter was valued as high as $90/ton. Based on current fertilizer prices (December 2010) of 60-45-50 (cents per pound of N-P_2O_5-K_2O), the value of a ton of poultry litter is around $60. This does account for the lower availability of N compared to commercial fertilizer. As the price of N, P and K varies, this value needs to be continuously adjusted. Also, due to variability, it is recommended that litter be analyzed for nutrients by a reputable laboratory before application rates are determined.

Poultry litter on cotton should be managed to provide preplant P and K and a portion of the total N requirement. The remainder of the N requirement should be applied as commercial fertilizer at sidedressing. For example, 2 tons/A of poultry litter preplant incorporated followed by 30 to 60

lb/A of sidedress N (depending on soil type) is a good, basic strategy. This approach should avoid unnecessary P buildup and should not cause rank growth, boll rot, or defoliation problems typically associated with excess N. In addition, the availability of N from poultry litter, because it is an organic material, is less predictable than from commercial fertilizer. Therefore, side-dressing with commercial fertilizer N assures adequate N availability when the crop needs it the most. The amount and timing of N released from litter depends on a number of factors, including soil pH, temperature, sand content, and available moisture. As a rule of thumb, 60% (or 36 lb N/ton of litter) is made available for crop uptake during the season if the manure is incorporated into the soil prior to planting. Most of the remaining N in the litter (about 40%) is either lost or "tied up" during the growing season and should not be considered for carryover to the next crop. Since N availability from poultry litter can be highly variable, petiole testing is strongly recommended. Build up of soil P and Zn are long-term concerns for using poultry litter as fertilizer. However, at the 2 ton/A rate, there are no short-term concerns for poultry litter use in cotton.

The only situation where poultry litter rates above 2 ton/A should be considered is where problems with "black root" are suspected. Black root is isolated to poorly-drained Flatwoods soils. Rates of 3 to 4 tons of poultry litter per acre have been shown to alleviate this problem dramatically. However, at the 4 ton/A rate excess soil P will build rapidly. Therefore, this solution should only be considered a short-term fix and not a long-term strategy.

Other By-Products

As landfill costs and regulations increase, more by-products are becoming available for land application on row crops such as cotton. These by-products are not only from the agricultural sector (such as poultry litter), but also from municipalities and industry. Examples include gin trash, mushroom compost, yard waste, biosolids, dairy manure, composts, fly ash, and wood ash. These materials may have some value as fertilizers, soil amendments, or liming materials. They may be free or available at very low cost. However, great caution is needed when considering the use of any by-product to ensure it can be used, safely, effectively, and economically.

Before considering the use of any by-product material on cotton, investigate the properties of the material. Find out what value it has (as either lime, fertilizer, soil amendment, or a combination), if it is safe (for example, low in heavy metal content and free of any toxins), how much it costs, and if it will handle and spread easily. Fortunately, any by-product material to be used as a fertilizer, lime, or soil amendment in Georgia must first be approved by the Department of Agriculture. Since by-products are unique, they should be investigated on a case-by-case basis.

VARIETY SELECTION

Choosing which variety to plant is one of the most critical steps in producing a cotton crop and achieving optimal yields and fiber quality. Currently, producers not only choose a variety based on genetic performance or yield potential, but also according to pest management traits or technology packages. The predominant technology systems that will be available in 2011 include (but aren't necessarily limited to) conventional, Roundup Ready Flex, Bollgard II/Roundup Ready Flex, Widestrike, Widestrike/Roundup Ready Flex, Liberty Link, and Bollgard II/Liberty Link. Now that DP 555 BR is no longer available for purchase, growers should strongly consider spreading their risks by planting multiple varieties. A single replacement for DP 555 BR is unlikely, however official variety trials and on-farm county variety trials in 2010 and 2011 illustrated that several varieties performed well in several environments. Considerations for

variety selection should also be catered to a range of planting dates, seedling vigor, water regimes (irrigated versus dryland), maturity classes, and plant growth characteristics, with the understanding that some varieties may perform better in certain situations than others.

The average lifespan of cotton varieties is becoming significantly shorter, therefore growers have little time to gain experience with these varieties. Growers must therefore adapt quickly to new varieties and gain as much experience with them as possible within a short time frame. Variety selection at the grower level should be based on research data and local field experience. Attention should be given to both yield and fiber quality. Sources of data include trials from university experiment stations and county demonstration plots, seed company trials, and consultant trials. Results of the UGA Uniform Cotton Variety Performance Evaluation Program are published on the UGA Cotton Web page at www.ugacotton.com, as well as the UGA Cotton Variety Performance Calculator, which is a simple tool for growers to use to compare performance of most modern varieties across Georgia. It is very important to observe multi-year and multi-location data when possible, as well as fiber quality characteristics of these varieties, which can also be found at www.ugacotton.com. It is even more important to look for varieties that perform consistently well across locations of a similar environment (irrigated vs. dryland). Some varieties may perform well at a particular location within a year, however their average yield acrossed similar environments may be much less, which may be an indicator of inconsistency or poor stability. Results from at least two years and several locations often provide a better indication of anticipated performance. Generally, the more years and locations the better, and while data are helpful, grower experience on the farm is the ultimate test. In addition, the adage, "Try a little, not a lot," is still the preferred approach when implementing new technologies, varieties, and production practices on the farm, if possible.

PLANTING DATES

Long term research has shown little yield difference in planting dates between April l and May 20. The "best" planting window varies yearly. Early planting while moisture persists increases the likelihood of successful planting in non-irrigated fields. However, early planting comes with risks, including possible seedling vigor and disease problems associated with cool and/or wet periods, premature cutout related to the coincidence of early fruiting and drought, and late season boll rot due to expected rains in late August or early September. Boll rot is frequent in areas in which boll opening coincides with rainfall, high humidity, and overcast conditions. Seed sprouting from the exposed seedcotton can also be a problem during the fall of some years if similar conditions prevail. In addition to these problems, significant yield loss and quality degradation can occur when lint is exposed to rainfall and wind.

Soil temperature is an important consideration for early planting. Generally, planting can safely proceed when the 4-inch soil temperatures reach 65^{o} F for 3 days and warming conditions are projected over the next several days (or approximately 50 DD-60's within 5 days of planting). Experience suggests that this is a very safe, conservative approach. It is critical that soil temperatures be 65^{o} F or more during the first 2 to 3 days after planting into moist soil, as imbibed seed are often killed by temperatures of 41^{o} F or below. Cotton seeds and seedlings are most sensitive to cool or cold tempertures during this time frame. Warm temperatures should also be likely within 5 days of planting, as temperatures below 50^{o} F can cause chilling injury to emerging seedlings.

Delaying planting until late April and early May has shown advantages in deep South Georgia. Irrigated cotton should usually be planted after May l, since the risk of having adequate moisture for getting a stand is eliminated, the possibility of boll rot from August rains is reduced, and thrips pressure is lessened. Also, boll opening and harvest-time rainfall risks are reduced and harvest can be accomplished from late September through November, normally our most likely rain-free period. For irrigated cotton near the Florida border, a planting date centered around May 10 should be a good strategy for reducing boll rot. Only short to medium maturity varieties should be planted after May 20 to 25.

Many south Georgia producers grow both cotton and peanuts. The occurrence of tomato spotted wilt virus (TSWV) has resulted in a shift in peanut planting to mid-May and has also delayed the initiation of peanut harvest to mid-September. Competition for labor at harvest has often forced South Georgia producers to choose between the two crops, most often with cotton harvest being delayed. There is the possibility that early plantings (early to mid-April) of short season cotton varieties under irrigation may allow harvest prior to peanut maturity. Early planting and subsequent early harvest may also be an avenue to enhance crop quality, as one of the major factors influencing overall crop quality is delayed defoliation and harvest. Potential benefits of this concept depends on favorable weather in early September, but planting a portion of the total crop helps "spread the risk." In some years, cotton that matures and opens in late August or early September is subjected to severe boll rot. In addition, unfavorable weather at boll opening may in fact undermine the attempt to capture quality with early planting of short season varieties. Thus, planting a major portion of ones crop in this way is not advised.

Weather prediction is an important part of agriculture. Ideally, an accurate understanding of future weather could guide planting so that fruiting coincides with abundant rainfall and that boll opening/harvest coincide with relatively rain-free periods. Unfortunately, neither accurate prediction nor control of weather exists. Weather--particularly rainfall--continues to be the single greatest factor influencing yield.

Double Crop

Double-crop or "June" cotton is feasible in the Coastal Plain, especially in lower South Georgia where the growing season is longer. Early, cool fall weather delays maturity and limits yield in some years, but cotton planted in early June has adequate yield potential under intensive management, especially with irrigation. Some UGA research shows a possible yield reduction of up to 30 percent when comparing full-season cotton planted in early May to June planted cotton after wheat harvest. Grower experience indicates increasing risk past the first week of June. The obvious limitation is an early frost or at least cool temperatures in mid to late October which inhibit boll maturation. In addition, because of the brevity of the potential fruiting period, timely rain or irrigation is absolutely necessary. Growers should be aware of crop insurance specifications related to late or double-crop cotton. Research studies along with grower experience indicate the following precautions or adjustments should be made when planting either as a double-crop after small grains or extremely late (near or after June 1):

1. Irrigation is strongly recommended to insure a vigorous stand and rapid stand establishment during the normally dry period in late May and early June. Likewise, dry weather is expected after mid-August and before boll maturity is completed.
2. Plant a short-season, fast-fruiting, early maturing variety.
3. Plant only 2 to 3 good quality seed/ft of row to alleviate the complications of late plantings and dense stands.

4. Protect the terminal bud from injury by thrips or worms. Generally, thrips pressure is less in late May and early June plantings as compared to April to mid-May planting dates. Also, prevent plant bug and stink bug damage to avoid delays in fruiting.
5. Avoid crop injury by over-the-top sprays or other misuse of herbicides to prevent stress and delayed maturity.
6. Prevent fruit shed and fruiting gaps by good insect control, balanced nutrition, and irrigation.
7. Don't try to rush the crop by over fertilizing with N. Use minimum soil applied rates (usually 25 to 30 percent less than on full season) and monitor nitrate levels with petiole tests to detect need for late sidedness or foliar N application. P and K could be applied to the previous crop, except for sandy land, to save time especially if a starter is used to give N for early season growth.
8. Monitor the crop closely by plant mapping, square retention counts, etc., so that problems can be diagnosed and corrected to prevent further delays in maturity.
9. Use mepiquat-containing plant growth regulators if needed to prevent excess vegetative growth and boll rot, and to promote earliness.
10. Use ethephon (Prep, Finish, First Pick, etc.) harvest aid to promote boll opening, allow earlier harvest, and avoid freeze damage.

PLANT AND FIBER DEVELOPMENT

Upland cotton (Gossypium hirsutum) is a perennial, tropical plant that has been bred and adapted for annual crop production in temperate climates. Cotton develops on a somewhat predictable schedule, although water and temperature stresses may have profound effects on growth rate.

Plant monitoring and mapping help determine if the plant is growing and fruiting normally. Assuming a lack of moisture stress or injury from one of many potential above or below ground pests, plant growth is primarily influenced by temperature. Plant development proceeds approximately according to a heat unit model which uses 60^{o} F as the base temperature. In this system, heat units are referred to as DD-60s and are calculated based on an average daily temperature ^{o}F minus 60^{o} F. The formula is listed below.

$$\frac{\text{Max } ^{o}\text{F} + \text{Min } ^{o}\text{F}}{2} - 60\ ^{o}\text{F} = \text{DD-60s}$$

For example, a day with a maximum of 86^{o} F and a minimum temperature of 70^{o} F produces 18 DD-60s, [$(86^{o} + 70^{o} / 2)\ 60^{o} = (156^{o}/ 2) - 60^{o} = 78^{o} - 60^{o} = 18$ DD-60's]. Temperatures above 93^{o} F should be entered in the formula at only 93^{o} F since growth probably does not increase at higher temperatures. Current and historical heat unit accumulations for numerous locations across the state can be referenced at the website for the Georgia Automated Environmental Monitoring Network (www.georgiaweather.net) via the UGA cotton web page at www.ugacotton.com . For numerous locations across the state, this Network website allows calculation of current heat unit accumulation and comparison with data from recent years.

The following chart estimates growth rate based on accumulated DD-60s. Because growth and development are dependent on many factors in addition to temperature, these numbers are only approximations. A detailed discussion of cotton plant growth and development can be found in UGA Extension Bulletin #B1252 at http://pubs.caes.uga.edu/caespubs/pubcd/B1252.htm.

		DD-60's	Days
From Planting to:	Emergence	50	4 to 14
	Pinhead square	550	35 to 45
	First bloom	940	55 to 70
	Peak bloom	1700	85 to 95
	First open boll	2150	115 to 120
	Harvest	2500 to 2700	140 to 160

Plant Growth Monitoring

Monitoring cotton growth rate gives an index of vigor and should usually be initiated by the 8 to 10 leaf stage. Because of the variability of row profiles and cultivation practices, plant height should be measured from cotyledons to the terminal bud, not from the ground up. Cotyledons are the pair of seed leaves first observed after emergence. They are attached to the mainstem directly opposite from each other. By general agreement across the Cotton Belt, the node at the point the cotyledons are attached is counted as Node 0. As growth progresses, the cotyledon leaves fall off, leaving two small nodes near the base of the plant.

The first true leaf is Node 1 and should be visible in the terminal within 7 to 10 days after emergence. Subsequent mainstem leaves will emerge at approximately 3-day intervals (4 days under cool or stressed conditions). These leaves occur singly at each node and the stem area between each leaf or node is called the internode. Fruiting branches (FB) normally begin to develop at node 5 to 7 from one of the two tiny buds in the leaf axil or point at which the mainstem leaf is attached. Fruiting branches develop a fruiting bud or square with a subtending leaf at 6-day intervals (possibly 7 to 9 day intervals under stress conditions) at one to three or more positions along the branch (referred to as FB1 for first position, FB2, etc.). The subtending leaf is a major source of photosynthate for the square, which flowers after about 21 days, and the boll, which develops and matures over a 6-week period after flowering. Vegetative branches (usually 2 or 3 per plant) develop at nodes or mainstem leaves below the first FB and sometimes from the second bud adjacent to a FB if the FB is injured. The goal for FB1 square retention at early bloom should be 80 percent. Experience in Georgia and in many other environments suggests that extremely high early retention rates may actually limit yields by limiting vegetative growth and total fruiting sites.

Cotton plants usually develop 21 to 23 nodes but an aggressive full-season varieties, may develop in excess of 25 nodes or mainstem leaves in long growing seasons with adequate moisture and/or moderate boll loads. Nodes beginning with numbers 5 to 7, and up to 20 to 22 potentially develop fruiting branches on which harvestable bolls develop. Cutout usually occurs when fewer than 5 nodes or mainstem leaves remain above the uppermost white flower (NAWF) at the first position (FB1). Boll retention in the top 2 to 3 nodes is usually very low since the plant is normally in cutout due to boll load, water, and/or nutrient stress.

Research indicates the crop can be defoliated when the uppermost, harvestable green boll is 4 nodes above the uppermost cracked boll (NACB = 4) without sacrificing yield and quality. When NACB is 5 or more, some yield or quality may be lost. Looking at this question from a different angle, a boll is sufficiently mature after accumulating about 750 DD-60s.

Plant Selection and Sampling for Monitoring Purposes

Usually, 20 normal plants should be counted / measured from each field beginning at the 8 to 10 leaf stage and on a weekly basis for maximum learning and database establishment. However, "short-cut" sampling where 8 to 10 plants or measurements are checked may be more practical for growers, county agents, and consultants.

Avoid plants with:

- Damaged terminals
- Spacings not like field average or plants next to skips or in clumps. Select the dominant plant in hill-dropped cotton
- 20 percent taller or shorter than field average.

Note: The following values are approximate and not well-defined by Georgia research

1. Plant Height (inches). Measure only from cotyledons to terminal bud.

2. Height/Node Ratio (HNR). Average plant height divided by total mainstem nodes = HNR or Vigor Index (inch/node).

	Vigor Index (Height/Node Ratio)		
Crop Stage	Normal	Stressed	Vegetative
Seedling Cotton =	0.5 to 0.75	-	-
Early Squaring =	0.75 to 1.2	0.7	>1.3
Large Square-1st bloom	1.2 to 1.7	<1.2	>1.9
Early bloom =	1.7 to 2.0	<1.6	>2.5
Early bloom + 2 weeks	2.0 to 2.2	<1.8	>2.5

3. Nodes Above White Flower (NAWF) at first position on fruiting branch (FB1):

Growth Stage	NAWF
Early Bloom	8 to 10
Peak Bloom	7 to 8
Cutout	<5

4. Ideal Plant (in very general terms)
   Height = 44 to 50 inches
   Total Nodes = 22 to 24
   HNR = 1.8 to 1.9
   First Fruiting Branch = node 6
   Fruiting Branches = 12 to 14
   Boll Retention = 67 percent or 8 to 10 FB1 bolls
   Cutout = begins node 18 to 20

Managing the crop according to information obtained by plant monitoring is not yet possible due to lack of enough baseline data and environmental control under Georgia conditions. Generally, when monitoring indicates the plant is stressed or growing abnormally, the cause should be determined and corrected as soon as possible. Timely soil, petiole, and tissue analysis can detect nutrient deficiencies or excesses. Of course, water stress can only be relieved by timely rain or irrigation. Stress may also be caused by herbicide injury, disease, nematode injury, soil compaction, and temperature extremes.

Mepiquat containing plant growth regulators can be used to regulate excess vegetative growth. If excessive vegetative growth is due to fruit loss, the cause of fruit loss should be detected quickly, especially if related to insects. Other causes of fruit loss may include cloudy weather, heat/drought stress, heavy boll load, and cutout. Maximum yields can be obtained by optimizing growth conditions through proper management.

Fiber Quality and Development

A cotton fiber is a single cell that generates from the surface of the seed and elongates resembling a hollow tube. Fiber quality issues in Georgia gained significant attention concerning the 2003 crop, however the release of new varieties in recent years has drastically improved fiber quality of Georgia cotton. In any given year, due to environmental conditions, light spot grades, short staple, and high micronaire may be encountered, therefore it is important to understand fiber development and important quality parameters, and potential actions that could help avoid discounts.

Fiber length uniformity is a calculation determined by dividing the average fiber length by the average of the upper half fiber lengths (staple). This is difficult to comprehend, but in essence, the uniformity index reflects how many short fibers are present. Short fibers lower yarn strength, reduce spinning efficiency, limit the use of lint for certain yarns, and increase imperfections in yarn. Uniformity can be influenced significantly by variety, boll feeding bugs, weathering of the open crop, and ginning. Relative comparisons of crop quality can be made by examining the Statewide Cotton Variety Testing data as well as other sources. The effects of boll feeding bugs on yield is well documented and we continue to learn about their effects on overall fiber quality. Weathering problems are aggravated by the limits of our harvest capacity, the interference of peanut harvest with cotton harvest (although the adoption of on-board module building pickers may help alleviate this issue), and our reluctance to push the crop toward rapid defoliation, boll opening, and harvest. Ginning can also have a profound affect on fiber uniformity. Excess heat (drying) and lint cleaning can result in breakage of fibers and reduce uniformity.

The two most important stages of development are fiber elongation and "thickening." Elongation occurs primarily during the first 20 days after flowering, while thickening (internal deposition of cellulose within the fiber) occurs from about 15 to 20 days after flowering and continues for about 30 days (until 45 days after flowering). Inside the "tube," rings or strands of cellulose are layered each day, intertwining and providing strength to the fiber.

The measure of elongation is staple, and the measure of internal fiber thickness is micronaire, often abbreviated as mike or sometimes mic. Variety, weather patterns, and boll feeding pest control play a role in determining fiber length and micronaire. Micronaire reflects the internal surface area or fill of the cotton fiber; that is, the thickness of the rings/layers formed within the cell. High or low micronaire generally corresponds to thicker or thinner deposites of cellulose, respectively. High micronaire (above 4.9) is usually associated with moisture or heat stress. Such conditions reduce boll set or boll size and concentrate carbohydrate production in fewer or smaller bolls, increasing cellulose deposition within individual fibers and increasing micronaire. Conversely, if stresses such as early frost or premature defoliation (from whiteflies, rain scald, etc.) curtail the development of bolls, low mic (below 3.5) may result. Low micronaire penalties are uncommon in Georgia, although a few early harvested bales in 1999 were docked for low micronaire because of late season whitefly damage, rain scald, and premature defoliation.

Certain varieties have a tendency towards high mic. In fact, because high micronaire means a slightly thicker and probably heavier fiber, cotton breeders recognize that elevated micronaire is often a quick step to higher yield. High micronaire generally means coarse fibers which have reduced spinning efficiency, and has implications concerning dye uptake.

Fiber quality is influenced by numerous factors, including weather, management, variety, and ginning. Both length and micronaire are influenced by environmental conditions. WHEN stress occurs determines the characteristic most affected.

PLANT POPULATION/SEEDING RATE

Aim for a final stand of 2 to 3 plants/ft of row. Calibrate planters to deliver 2.5 to 4 seeds/ft (2 to 3 in irrigated fields). Increase planting rate if seed quality is poor or in fields in which seedling diseases, soil crusting, or otherwise poor emergence are a problem. Calibrate planters for each variety to be planted. Seed sizes of different varieties range from 4000 to 6500 seed/lb and significantly affect the number of seed planted. Therefore, final rates may range from less than 6 to more than 8 lb/A. Thick stands (5 or more plants/ft) are undesirable but sometimes occur unintentionally. They can produce satisfactory yields under careful management of nitrogen, moisture, and insects, though dense stands tend to increase the node number at which plants begin fruiting.

Because the “per acre” technology costs of transgenic varieties are directly linked to seeding rates, growers are often tempted to minimize the number of seed/ft. In research trials conducted from 1995 to 1997, rates as low as 2 seed/ft resulted in plant stands ranging from 1.2 to 1.9 plants/ft and maximum lint yield over the 3 year study. Practically, a target of 2.5 seed/ft is a reasonable trade-off for economizing with transgenic cotton. In a hill-drop planting system, which is often used to overcome the adverse effects of soil crusting, this seeding rate would be equivalent to 2 seed every 8 to 10 inches**.** Reducing seeding rates below 2.5 seed/ft often increases the chance of poor stand establishment and adverse effects on plant canopy structure or architecture, especially if environmental conditions are not suitable for rapid stand establishment. Skippy stands can reduce yields, delay maturity, and allow sunlight penetration through the canopy to be utilized by weeds.

PLANTING

"Knock-off" beds and plant in the center of a smooth uniform surface 12 to 16 inches wide. Wet beds may need to be leveled 1 to 4 hours ahead of planting. Equip planters with 6 to 8 inch wide depth bands or gauge wheels, or 12 to 16 inch wide gauge shoes to provide seed depth control and smooth drill area. Set planters to place seed 0.5 to 1 inch deep. Shallower planting may be more appropriate if soil crusting occurs or if other emergence complications are expected. The shallow depth range is also preferred for "dusting in" in dry soil and/or cool-weather planting, a greater planting depth is preferred for warmer weather planting if moisture is sufficient at planting and for several days thereafter. Cotton is very sensitive to deep planting, especially in crusting soils or when soil moisture depletes rapidly. Open center press wheels and low press wheel loading are preferred to minimize soil crusting.

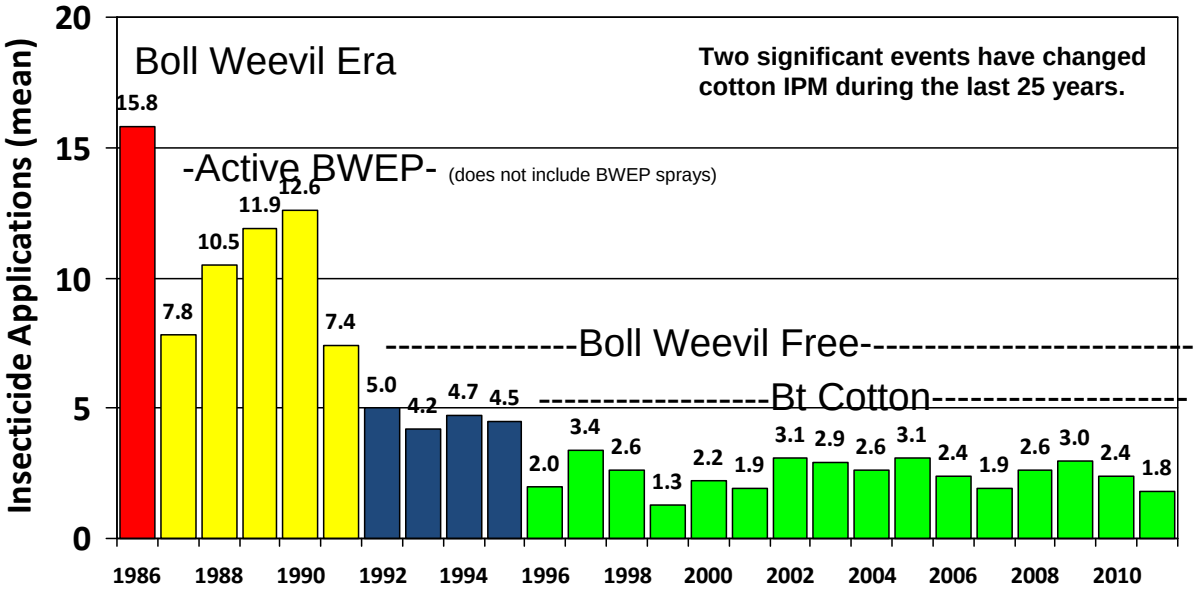
If "rip-plant" equipment is used, off-set row drill 2 to 3 inches to one side of ripper shanks to reduce risk of stand loss from "fall-in.” Contamination of the preplant incorporated herbicide treated zone with untreated soil resulting in grass emergence in the drill occasionally occurs

behind ripper-planters. This can be minimized by using ripper shanks with a sharp rather than flat leading edge and by not planting in wet soil.

With good soil moisture and warm temperatures at planting, seedlings usually begin to emerge in 5 to 7 days with full stand in 8 to 11 days, but can be delayed or complicated by seedling diseases or rapid moisture depletion. Physical hazards to establishing stands that occasionally occur during this period include hard soil crusts and blowing sand. The adverse effects of both can be greatly reduced with rotary hoe or rolling cultivator operations. These implements should be operated just deep enough to break the crust. An irrigation of 0.3 to 0.5 inches can be used to soften or weaken a crust and accomplish the same objective. Timing this operation is critical. If a hard crust is evident when the seed root is 0.6 to 0.75 inches long, it should be broken immediately, being careful not to completely uproot more than 20 to 25 percent of the seedlings. Soil crust strength can be measured with a small pocket penetrometer. Emergence decreases rapidly at soil strengths above 10 psi when cotton is planted deeper than 1 inch.

INSECT MANAGEMENT

Cotton insect management has changed dramatically since the successful elimination of the boll weevil as an economic pest and the commercialization of Bt transgenic cotton. Prior to elimination of the boll weevil, Georgia producers annually applied 10 to 20 insecticide treatments each season for control of boll weevils and other pests. Upon elimination of the boll weevil as an economic pest, the number of insecticide applications was reduced to four or five during 1992 to 1995. Utilization of Bt cotton, commercialized in 1996, has further reduced the need for insecticides by eliminating the need to treat tobacco budworm and significantly reducing the need to treat for corn earworm. Producers in Georgia continue to fully utilize an integrated approach to pest management (IPM) utilizing a variety of control tactics rather than relying solely on one method of control such as insecticide use. Cultural practices, variety selection, biological control, and insecticides used on an as-needed basis are the building blocks of an IPM program. Pests are managed so that economic damage and harmful environmental side effects are minimized while maximizing profits. In most IPM programs insecticide use decreases resulting in lower production costs, delayed resistance problems, and improved competitiveness and profitability. A successful and economical cotton pest management program mandates the use of this multi-tactical or IPM approach to insect control.



Source: Beltwide Cotton Conferences

Figure 1. Mean insecticide applications applied on Georgia cotton, 1986-2011. The Boll weevil Eradication Program was initiated during the fall of 1986.

Scouting

Insect scouting is a **necessity**. All fields, both Bt and non-Bt cotton, should be scouted on a regular basis. Insect populations vary from year to year and even from field to field during the year. Fields should be scouted at least every five days, some scouts monitor fields twice per week. Although not recommended, once a week scouting may be acceptable on Bt cotton but there is associated risk with this reduction in field visits. **Once a week scouting on non-Bt cotton is unacceptable**. Management decisions should be made independently for each field based on the pest(s) situation. Accurate monitoring of fields will allow growers to make timely applications of the correct insecticide(s) and rates to prevent damage from reaching economic levels. (See ***Cotton Scout Handbook*** for a detailed discussion of insects and scouting techniques and Appendix I for insecticides, rates, and thresholds.)

Beneficial Insects

Numerous species of predatory and parasitic insects are present in Georgia cotton. These natural controls are our most economical pest management tools, and conservation of beneficial populations should be strongly considered, especially during the early and early-middle portions of the growing season. Later in the season, natural enemies tend to re-colonize fields rapidly from the large populations in the adjacent landscape. Big-eyed bugs, pirate bugs, fire ants, and *Cotesia* wasps are examples of important beneficials. The presence of these natural controls may delay or even prevent the need to treat for some insect pests. The use of beneficials should be maximized in attempts to reduce production costs.

Thresholds

Action or economic thresholds have been established for major cotton insect pests and are defined as the pest density at which action must be taken to prevent economic damage. The decision to apply an insecticide should be based on scouting and the use of thresholds. Thresholds for major cotton insects found in Appendix I should serve as a guide for decision making. **Scheduled or automatic applications of insecticides should be avoided**. An unnecessary application can be more costly than just the cost of the insecticide due to the destruction of beneficial insects. In the

absence of beneficial insects, the risk of economic infestations for many pests increases. Application of insecticides on an as-needed basis allows beneficial insects to be preserved and reduces the likelihood of secondary pest outbreaks such as beet armyworm and spider mites.

Resistance Management

In a population of insects, insecticide resistance levels to a particular class of insecticide increase each time that class of insecticide is used. Once an insecticide is used, its level of effectiveness will likely be reduced against subsequent generations within the season. Therefore **alternating the use of insecticide classes on different generations** of insects during the season is a recommended resistance management tactic. Since most cotton insect pests are highly mobile, such a strategy will be most effective if adopted by all producers in a large geographic area.

Thrips Management

Thrips are consistent and predictable pests of seedling cotton that infest cotton at emergence. Thrips initially feed on the lower surface of cotyledons and then in the terminal bud of developing seedlings. Excessive feeding results in crinkled malformed true leaves, stunted plants, delayed maturity, reduced yield potential, and in severe cases reduced stands.

At-plant systemic insecticides provide consistent yield responses and are used by most growers for early season thrips control. In-furrow applications or seed applied systemic insecticides are taken up by the plant as it germinates and develops providing protection during early growth stages. Commonly used at plant thrips insecticides include Temik 15G applied in the seed furrow and the commercial seed treatments imidacloprid (Gaucho, Aeris Seed Applied System, and Acceleron-I) and thiamethoxam (Cruiser, Avicta Complete Cotton, and Acceleron-N). Temik, which has been the standard at-plant insecticide used in Georgia cotton for many years, is no longer being manufactured and available supplies will be extremely limited. Thus growers will be using alternative at-plant treatments such as the commercial seed treatments.

Supplemental foliar sprays may be needed if environmental conditions are not conducive for uptake of at-planting systemic insecticides or if heavy thrips infestations occur. Systemic foliar insecticides should be applied to cotton which had an at-plant systemic insecticide when 2-3 thrips per plant are counted and immatures are present. The presence of numerous immatures suggests that the at-plant systemic insecticide is no longer active. If no at-plant thrips insecticide is used, multiple well timed foliar applications will be needed.

The following factors related to thrips biology and ecology should be considered when planning thrips management programs:

- Thrips infestations are generally higher on April and early May planted cotton compared with later planting dates.
- Thrips infestations are lower in reduced tillage systems compared with conventionally tilled systems (winter cover crops should be killed at least 3 weeks prior to planting and no green vegetation should be present at planting).
- Seedling injury and potential yield impacts from thrips feeding are compounded by slow seedling growth due to cool temperatures or other plant stresses.
- A rapidly growing seedling can better tolerate thrips feeding.

- Seedlings become more tolerant of thrips feeding as they develop; small seedlings (<2-leaf) are more sensitive to thrips injury in terms of yield loss compared with 3-4 leaf seedlings.
- Slow growing seedlings will remain in the thrips "susceptible window" for a more extended time compared with a rapidly growing seedling; it is unlikely that seedlings which have reached the 4-leaf stage and are growing rapidly will benefit from supplemental foliar sprays.

Commercial seed treatments including imidacloprid or thiamethoxam provide similar levels of thrips control and are active on thrips for about 3 weeks after planting. Research and observation have shown that a supplemental foliar spray is often needed in addition to a commercial seed treatment when thrips infestations are high. We typically expect to see higher thrips infestations on early planted cotton in conventional tillage systems. Thus, **a foliar thrips systemic insecticide should be applied at the 1-leaf stage in conventional tilled fields planted prior to May 10 when a commercial seed treatment is used**. In most situations this program will provide good thrips control, but the fields should be scouted regularly for thrips and injury following the foliar spray. In fields planted after May 10 or where reduced tillage is used, the risk of high thrips infestations is lower and an automatic foliar spray should not be applied; scout and treat when thresholds are exceeded.

Aphid Management

Cotton aphid is a consistent and predictable pest of cotton in Georgia. Aphids will typically build to moderate to high numbers and eventually crash due to a naturally occurring fungus. This fungal epizootic typically occurs in late June or early July depending on location. Once the aphid fungus is detected in a field (gray fuzzy aphid cadavers) we would expect the aphid population to crash within a week.

Aphids feed on plant juices and secrete large amounts of "honeydew", a sugary liquid. The loss of moisture and nutrients by the plants has an adverse effect on growth and development. This stress factor can be reduced with the use of an aphid insecticide. However, research conducted in Georgia fails to consistently demonstrate a positive yield response to controlling aphids. Invariably, some fields probably would benefit from controlling aphids during some years. Prior to treatment, be sure there is no indication of the naturally occurring fungus in the field or immediate vicinity. Also consider the level of stress plants are under, vigorous and healthy plants appear to tolerate more aphid damage than stressed plants.

Tobacco Budworm / Corn Earworm Management

Tobacco budworm and corn earworm comprise the Heliothine complex. Although these two species appear very similar in the egg and larval stages and cause similar damage, they are different insects and their susceptibility to specific insecticides differ. Three generations of tobacco budworm infest cotton each year. The first generation usually occurs in early June, the second in early July, and the last during August. These time periods vary from year to year and locality within the state but generally occur on a four-week cycle. Two generations of corn earworm infest cotton. The first corn earworm infestation is typically observed during mid-July when corn begins to dry down and a second generation occurs approximately four weeks later. Late in the season overlapping generations of both species are often observed.

It is important that we accurately distinguish between these two species. The adult or moth stage of tobacco budworm and corn earworm can be easily distinguished (See ***Cotton Scout Handbook*** for a detailed discussion of insects and scouting techniques). Observation of "flushing" moths during scouting and other field activities provides an opportunity to recognize which is the predominant species. Tobacco budworm and corn earworm larvae can be distinguished upon careful examination with a hand lens or use of a dissecting microscope (see http://www.gaipm.org/cotton/larvaid.html for identification procedures). Populations of tobacco budworm infesting Georgia cotton are resistant to the pyrethroid class of insecticides and therefore **non-pyrethroid insecticides should be used to control tobacco budworm**.

On non-Bt cotton insecticide applications should target larvae 1/4 inch in length or less (less than 3 days of age). Coverage and penetration of the canopy with insecticide sprays are important. These basic principles of insect control are especially important if high populations or difficult to control larvae are present.

Distinguishing tobacco budworm and corn earworm is also important in Bt cotton. Corn earworm is less susceptible to the Bt toxin compared with tobacco budworm. Supplemental insecticide treatments may be needed for corn earworm control on Bt cotton whereas Bt cottons provide excellent control of tobacco budworm.

Pyrethroid Resistant Tobacco Budworm

Tobacco budworm populations in Georgia exhibit moderate to high levels of pyrethroid resistance. Erratic and often unacceptable control would be expected if pyrethroids were used for control of tobacco budworm. In areas where tobacco budworm commonly infests cotton, producers should utilize Bt cotton which has provided excellent control. On non-Bt cotton, pyrethroid insecticides should **not** be used for control of tobacco budworm. Non-pyrethroid insecticides should be used in a timely basis for control of tobacco budworm on non-Bt cotton.

Difficult to Control Corn Earworm

Susceptibility of corn earworm to pyrethroid insecticides has declined in some areas of the US during recent years. Elevated LD50s (the lethal dose to kill 50 percent of a population) of some corn earworm collections have been observed in LA, VA, and TX, as well as Georgia. During recent years, corn earworm susceptibility to pyrethroids has been monitored using cypermethrin (pyrethroid) treated glass vials. To conduct Adult Vial Tests, moths are collected from pheromone traps and placed in pyrethroid treated vials and mortality is evaluated 24 hours later. Since 2000 we have observed a trend for increased survival in pyrethroid treated vials. Increased survival suggests that populations will be more difficult to control with a field application of a pyrethroid insecticide. Results of Adult Vial Tests will be reported in the Cotton Pest Management Newsletter (found online at http://ugacotton.com) as needed which is published regularly during the growing season.

Recommendations for control of corn earworm include the use of medium to high rates of pyrethroids for low to moderate infestations. Under heavy pressure, consider adding an ovicide or another larvacide with the pyrethroid. Efficacy of pyrethroid sprays should be evaluated three days after application. If poor control of corn earworm is observed and other factors of poor control (coverage, rate, timing of application) can be ruled out, a non-pyrethroid insecticide should be used. We cannot predict if this problem will develop further or if, when, or where it may occur.

Bt Cotton Management

Commercially available Bt cotton technologies include Bollgard II and WideStrike. Bt cottons are not immune from economic damage from caterpillar pests and have no activity on "bug" pests such as plant bugs and stink bugs. Thus, scouting for insect pests in Bt cotton (both caterpillar and bug pests) continues to be important.

Bollgard II is a two-gene Bt cotton that contains the Cry1Ac and Cry2Ab toxins and WideStrike is a two-gene Bt cotton that contains the Cry1Ac and Cry1F toxins. Both Bollgard II and WideStrike provide excellent control of tobacco budworm and good control of most caterpillar pests. However, supplemental insecticides may be needed for pest such as corn earworm, fall and beet armyworm, and soybean loopers. During recent years the most common caterpillar pests needing supplemental treatment in two-gene Bt cottons is fall armyworm in Bollgard II cottons and corn earworm in WideStrike cottons. Be sure to monitor these cottons for early signs of infestation as the presence of numerous moths, eggs, or small larvae should influence insecticide selection when applications are made for other pests such as stink bugs.

Bt Cotton Resistance Management

Since Bt cotton provides continuous season long activity against tobacco budworm and corn earworm, there is a high potential for one or both of these pests to quickly develop resistance if an effective resistance management plan is not implemented. Resistance management in Bt cotton uses the refuge approach to maintain a pool of susceptible moths to mate with any resistant moths that may survive on Bt cotton. Producers should maintain full knowledge of the details and follow resistance management requirements of use agreements with suppliers of transgenic seed or technology**.** Weedy host plants and non-cotton agronomic crops currently serve as a natural refuge for Bollgard II and WideStrike cottons.

Stink Bug Management

The pest status of stink bugs in Georgia cotton and other areas of the Southeast have been elevated in recent years due to the reduction of broad spectrum insecticide use. Eradication of the boll weevil, greater utilization of natural controls, commercialization of Bt transgenic cotton, and development of caterpillar specific insecticides have all contributed to the reduced use of broad spectrum insecticides. Routine use of broad spectrum insecticides, such as pyrethroids to control other pests in years past suppressed stink bugs below economic levels. In the absence of coincidental control of stink bugs, populations can build to damaging levels.

The most important species of stink bugs that we observe in Georgia are the southern green and brown stink bugs. Southern green is generally the most common. Organophosphate insecticides such as Bidrin provide excellent control of southern green and brown stink bugs. Pyrethroids provide good control of southern green stink bugs and are useful when populations of both caterpillar pests and stink bugs infest the same field. Research indicates that the brown stink bug is less susceptible to pyrethroids compared with southern green stink bug (control of brown stink bugs with pyrethroids increases when high rates are used). If brown stink bugs are present at economic levels an organophosphate insecticide should be used. However, the key to successful management of stink bugs in cotton is to know when and if an insecticide application is needed.

Stink bugs have piercing sucking mouthparts and damage cotton by feeding on the seeds of developing bolls. Stink bugs feed by piercing the boll wall with their beak and injecting a digestive enzyme into the boll in or near the seed to soften or dissolve plant tissues so the bug can remove them. In addition to physical damage, this process allows for entry of rot organisms that

contributes to degradation of bolls reducing yield and quality. Bolls damaged by stink bugs may show sunken, purple spots on the outside boll wall; however this is not a reliable indicator of stink bug damage. Internal symptoms of injury are a much better indicator of stink bug feeding and include stained or yellowish lint and/or callous growths or warts on the inner surface of the boll wall where the stink bug penetrated the boll. The wart or callous growth on the inner surface of the boll wall will form within 48 hrs on developing bolls. As bolls mature and open, damage often appears as matted or tight locks with localized discoloration that will not fluff. Severely damaged bolls may not open at all.

Scouting for stink bugs should be a priority as plants begin to set bolls. In addition to being observant for nymphs and adult stink bugs, scouts should assess stink bug populations by quantifying the percentage of bolls with internal damage. Estimating boll injury has proven to be a reliable technique for timing insecticide applications when needed. Bolls are considered injured if stained lint is observed or a warty growth is present on the inner surface of the boll wall. Bolls approximately the diameter of a quarter should be examined. Bolls of this age are preferred feeding sites for stink bugs can be easily squashed between your thumb and forefinger. It is important that bolls of this size (soft) are selected. If bolls which are the diameter of a quarter are not present, i.e. the first or second week of bloom, sample the largest bolls present. Monitor boll retention during the first week of bloom; if small bolls are damaged by stink bugs they will often be aborted (small bolls which are damaged by stink bugs will often have "jelly-like" contents in some locules). In addition to stink bugs, other bug species such as tarnished plant bug and leaf-footed bugs may injure developing bolls.

The number of bolls per plant which are susceptible to stink bugs is not constant and varies during the year. The greatest number of susceptible bolls per plant generally occurs during weeks 3-5 of bloom. During early bloom there are relatively few bolls present. During late bloom, many bolls are present but only a limited number may be susceptible to stink bug damage (individual bolls are susceptible to stink bugs in terms of yield loss until approximately 25 days of age). A **dynamic threshold** which varies by the number of stink bug susceptible bolls present is recommended for determining when insecticide applications should be applied for boll feeding bugs.

The boll injury threshold for stink bugs should be adjusted up or down based on the number of susceptible bolls present. Use a 10-15% boll injury threshold during weeks 3-5 of bloom (numerous susceptible bolls present), 20% during weeks 2 and 6, and 30%(+) during weeks 7(+) of bloom (fewer susceptible bolls present). Environmental factors such as drought and/or other plant stresses may cause susceptible boll distribution to vary when normal crop growth and development is impacted; thresholds should be adjusted accordingly. Detection of 1 stink bug per 6 feet of row would also justify treatment.

Week of bloom	Stink Bug Threshold (% Damage)
1	Retention
2	20
3	10-15
4	10-15
5	10-15
6	20
7+	30+

Research suggests that in addition to yield loss, excessive stink bug damage can reduce fiber

quality characteristics. Fiber characteristics associated with length, maturity, and color are reduced when excessive stink bug damage is present.

Stink bugs are a primary pest of Georgia cotton and require management. Not all fields will require treatment, but for profit maximization scouting and treating on an as-needed basis is required. Fields at highest risk for stink bug infestations are those that have not received a broad spectrum insecticide during the past two weeks. Stink bug infestations are often first observed near field edges (especially near a peanut planting). Some innovative growers have chosen to scout and treat cotton near field edges independent of the entire field.

Boll Weevil Eradication Program

The BWEP is in the containment phase. Activities include reduced trapping but active spraying in areas where boll weevils are detected. Boll weevils are the responsibility of the program, so growers with suspected boll weevil problems should notify their local field supervisors. Everyone growing cotton is required to pay a per bale assessment for the BWEP. Boll weevil traps will be placed in fields by late July and monitored every three weeks for reinfestation. It is vitally important that traps are standing and functional. If a trap is accidentally knocked down or destroyed, stand it back up or contact your local field supervisor. All attempts to prevent reinfestations should be taken. A common means for boll weevils to reenter Georgia is on used farm machinery such as pickers and module trucks. If you plan to acquire machinery from a non-eradicated area, be sure it is boll weevil free. Contact the BWEP for more details.

Appendix I: COTTON INSECT CONTROL

Phillip M. Roberts, Extension Entomologist; John Ruberson, Research Entomologist; Mike Toews, Research Entomologist

PEST	INSECTICIDE	FORMULATION PER ACRE	LBS. ACTIVE PER ACRE	REMARKS
Aphid (Cotton)	acetamiprid (Assail 30SG)	1.5-2.5 ozs	0.028-0.047	Apply when aphids are abundant and seedling leaves are severely curled, or when "honeydew" is present in older cotton. A naturally occurring fungal disease often eliminates the need for sprays, but this epidemic occurs only after aphid populations reach high levels and tends to be less effective late in the season.
	dicrotophos (Bidrin 8)	4.0-8.0 ozs	0.25-0.50	
	flonicamid (Carbine 50WG)	1.4-2.8 ozs	0.044-0.088	
	imidacloprid (Admire Pro 4.6)	0.9-1.7 ozs	0.032-0.061	
	thiamethoxam (Centric 40 WG)	1.25-2.0 ozs	0.031-0.05	
Beet Armyworm	emamectin benzoate (Denim 0.16)	6-8 ozs	0.0075-0.01	Apply when 10% of squares are damaged, 10% of blooms are infested, or when 10 active “hits” are observed per 300 row feet.
	diflubenzuron (Dimilin 2L)	4-8 ozs	0.0625-0.125	
	flubendiamide (Belt 4SC)	2-3 ozs	0.0625-0.094	
	indoxacarb (Steward 1.25EC)	9.2-11.3 ozs	0.09-0.11	
	methoxyfenozide (Intrepid 2F)	4 ozs	0.0625	
	novaluron (Diamond 0.83EC)	6-12 ozs	0.039-0.077	
	chlorantraniliprole (Prevathon 0.43)	14-27 ozs	0.047-0.09	
	spinosad (Tracer 4)	2.14-2.9 ozs	0.067-0.089	
Bollworm/Tobacco Budworm	**NON-PYRETHROIDS**			On non-Bt cotton apply when 8 small larvae are found per 100 terminals prior to first insecticide treatment, or when 5 larvae are found after first spray. Due to the threat of pyrethroid resistance, non-pyrethroid insecticides are recommended for control of tobacco budworm. Resistance management: Do not treat successive generations with insecticides that have the same mode of action. Bt Cotton containing the Bollgard II or Wide Strike Bt genes are effective tools for use in bollworm and tobacco budworm management programs. Apply insecticide on Bt cotton when 8 larvae (1/4 inch or greater in length) are found per 100 plants.
	emamectin benzoate (Denim 0.16)	8-12 ozs	0.01-0.015	
	flubendiamide (Belt 4SC)	2-3 ozs	0.063-0.094	
	indoxacarb (Steward 1.25EC)	11.3 ozs	0.11	
	methomyl (Lannate LV 2.4)	1.5-2 pts	0.45-0.6	
	profenofos (Curacron 8E)	0.75-1 pt	0.75-1.0	
	chlorantraniliprole (Prevathon 0.43)	14-27 ozs	0.047-0.09	
	spinosad (Tracer 4)	1.4-2.9 ozs	0.045-0.089	

COTTON INSECT CONTROL (continued)

PEST	INSECTICIDE	FORMULATION PER ACRE	LBS. ACTIVE PER ACRE	REMARKS
Bollworm/Tobacco Budworm (cont.)	**PYRETHROIDS**			Tobacco budworm is resistant to pyrethroid insecticides. Pyrethroids should not be used for control of tobacco budworm.
	beta-cyfluthrin			
	(Baythroid XL 1)	1.6-2.6 ozs	0.0125-0.02	
	bifenthrin			
	(Brigade 2EC)	2.6-6.4 ozs	0.04-0.1	
	(Discipline 2EC)	2.6-6.4 ozs	0.04-0.1	
	(Fanfare 2EC)	2.6-6.4 ozs	0.04-0.1	
	cypermethrin			
	(Ammo 2.5EC)	2-5 ozs	0.04-0.1	
	(Up-Cyde 2.5EC)	2-5 ozs	0.04-0.1	
	esfenvalerate			
	(Asana XL 0.66)	5.8-9.6 ozs	0.03-0.0495	
	gamma-cyhalothrin			
	(Prolex 1.25)	1.28-2.05 ozs	0.0125-0.02	
	(Declare 1.25)	1.28-2.05 ozs	0.0125-0.02	
	lambda-cyhalothrin			
	(Karate w/ Zeon 2.08)	1.6-2.56 ozs	0.025-0.04	
	(Karate EC 1)	3.2-5.12 ozs	0.025-0.04	
	(Silencer 1)	3.2-5.12 ozs	0.025-0.04	
	zeta-cypermethrin			
	(Mustang Max 0.8)	2.64-3.6 ozs	0.0165-0.0225	
Bollworm/Tobacco Budworm (ovicides)	methomyl			Apply in a tank-mix with a larvacide when large numbers of eggs are present.
	(Lannate LV 2.4)	0.4-0.75 pt	0.12-0.225	
	profenofos			
	(Curacron 8E)	0.125-0.25 pt	0.125-0.25	
Cutworm (seedling cotton)	acephate			Apply when stand is threatened. Spot treatment is often adequate.
	(Orthene 97)	0.75 lb	0.72	
	(Orthene 90S)	0.8 lb	0.72	
	(Acephate 97)	0.75 lb	0.72	Pyrethroids provide good control of cutworms at low rates. See insecticide label for use rate.
	(Acephate 90)	0.8 lb	0.72	
	chlorpyrifos			
	(Lorsban 4E)	1.5-2 pts	0.75-1.0	
	(Chlorpyrifos 4E)	1.5-2 pts	0.75-1.0	
	Pyrethroids	see remarks		

COTTON INSECT CONTROL (continued)

PEST	INSECTICIDE	FORMULATION PER ACRE	LBS. ACTIVE PER ACRE	REMARKS
Fall Armyworm	chlorantraniliprole (Prevathon 0.43)	14-27 ozs	0.047-0.09	Apply when 15 larvae are found per 100 plants. Control of large larvae (›½ inch in length) is difficult; higher rates should be used.
	diflubenzuron (Dimilin 2L)	4-8 ozs	0.0625-0.125	
	emamectin benzoate (Denim 0.16)	8-12 ozs	0.01-0.015	
	flubendiamide (Belt 4SC)	2-3 ozs	0.0625-0.094	
	indoxacarb (Steward 1.25EC)	9.2-11.3 ozs	0.09-0.11	
	methomyl (Lannate LV 2.4)	1.5-2 pts	0.45-0.6	
	methoxyfenozide (Intrepid 2F)	4-10 ozs	0.0625-0.156	
	novaluron (Diamond 0.83EC)	6-12 ozs	0.39-0.77	
	profenofos (Curacron 8E)	0.75-1.0 pt	0.75-1.0	
	spinosad (Tracer 4)	2.14-2.9 ozs	0.067-0.089	
	Pyrethroids	See remarks		Pyrethroids at high rates provide good suppression of larvae less than 1/8 inch in length.
Plant Bugs and Fleahoppers	acephate (Orthene 97) (Orthene 90S) (Acephate 97) (Acephate 90)	 0.25-0.50 lb 0.25-0.5 lb 0.25-0.50 lb 0.25-0.5 lb	 0.24-0.49 0.225-0.45 0.24-0.49 0.225-0.45	Apply when plants are retaining less than 80% of pinhead squares and numerous plant bugs are observed.
	dicrotophos (Bidrin 8)	4-8 ozs	0.25-0.5	
	imidacloprid (Admire Pro 4.6)	0.9-1.7 ozs	0.032-0.061	
	novaluron (Diamond 0.83EC)	9-12 ozs	0.058-0.077	Diamond is an insect growth regulator and will not control adults.
	oxamyl (Vydate C-LV 3.77)	8.5-17 ozs	0.25-0.50	
	thiamethoxam (Centric 40 WG)	2 ozs	0.05	
Soybean Looper	emamectin benzoate (Denim 0.16)	8-12 ozs	0.01-0.15	Treatment is necessary when soybean loopers threaten to defoliate cotton with immature bolls.
	flubendiamide (Belt 4SC)	2-3 ozs	0.0625-0.094	
	indoxacarb (Steward 1.25EC)	6.7-9.2 ozs	0.065-0.09	
	methoxyfenozide (Intrepid 2F)	4-10 ozs	0.039-0.077	
	novaluron (Diamond 0.83EC)	6-12 ozs	0.067-0.089	
	spinosad (Tracer 4)	2.14-2.9 ozs	0.067-0.089	

COTTON INSECT CONTROL (continued)

PEST	INSECTICIDE	FORMULATION PER ACRE	LBS. ACTIVE PER ACRE	REMARKS
Spider Mites	abamectin Agri-Mek 0.15)	8-16 ozs	0.009-0.18	Apply when mites are spreading. Spot treatment may be adequate. Thorough coverage is essential; a second application may be necessary.
	bifenthrin*			
	(Brigade 2EC)	3.8-6.4 ozs	0.06-0.1	*Bifenthrin may not control spider mite populations (suppression).
	(Discipline 2EC)	3.8-6.4 ozs	0.06-0.1	
	(Fanfare 2EC)	3.8-6.4 ozs	0.06-0.1	
	dicofol (Dicofol 4)	2-3 pts	1.0-1.5	
	etoxazole (Zeal 72 WSP)	0.66-1.0 oz	0.03-0.045	
	fepyroximate (Portal 0.4)	16-32 ozs	0.05-0.1	
	propargite (Comite II 6)	1.25-2.25 pts	0.937-1.687	
	profenofos (Curacron 8E)	0.5-0.75 pt	0.5-0.75	
	spiromesifen (Oberon 2SC)	8-16 ozs	0.125-0.25	
Stink Bugs	**ORGANOPHOSPHATES**			The boll injury threshold should be adjusted up or down based on the number of susceptible bolls present. Use a 10-15% boll injury threshold during weeks 3-5 of bloom (numerous susceptible bolls present), 20% during weeks 2 and 6, and 30%(+) during weeks 7(+) of bloom (fewer susceptible bolls present). Detection of 1 stink bug per 6 row feet would also justify treatment. Organophosphates should be used for control of brown stink bugs.
	acephate			
	(Orthene 97)	0.5-0.75 lb	0.49-0.72	
	(Orthene 90S)	0.54-0.8 lb	0.49-0.72	
	(Acephate 97)	0.75 lb	0.72	
	(Acephate 90)	0.8 lb	0.72	
	dicrotophos			
	(Bidrin 8)	4-8 ozs	0.25-0.5	
	methyl parathion	(several formulations)	0.5	
	PYRETHROIDS			
	beta-cyfluthrin			
	(Baythroid XL 1)	1.6-2.6 ozs	0.0125-0.0205	
	bifenthrin			
	(Brigade 2EC)	2.6-6.4 ozs	0.04-0.1	
	(Discipline 2EC)	2.6-6.4 ozs	0.04-0.1	
	(Fanfare 2EC)	2.6-6.4 ozs	0.04-0.1	
	esfenvalerate			
	(Asana XL 0.66)	5.8-9.6 ozs	0.03-0.0495	
	gamma-cyhalothrin			
	(Prolex 1.25)	1.28-2.05 ozs	0.0125-0.02	
	(Declare 1.25)	1.28-2.05 ozs	0.0125-0.02	
	lambda-cyhalothrin			
	(Karate w/ Zeon 2.08)	1.6-2.56 ozs	0.025-0.04	
	(Karate EC 1)	3.2-5.12 ozs	0.025-0.04	
	(Silencer 1)	3.2-5.12 ozs	0.025-0.04	
	zeta-cypermethrin			
	(Mustang Max 0.8)	2.64-3.6 ozs	0.0165-0.0225	

COTTON INSECT CONTROL (continued)

PEST	INSECTICIDE	FORMULATION PER ACRE	LBS. ACTIVE PER ACRE	REMARKS
Thrips (seedling cotton), At-Plant Treatments	acephate			
	(Orthene 97ST)	Commercial seed	treatment	
	(Orthene 97)	0.5-1.0 lb	0.49-0.97	
	(Orthene 90S)	0.56-1.1 lb	0.5-1.0	
	(Acephate 97)	0.5-1.0 lb	0.49-0.97	Apply acephate as a spray into the seed furrow at planting.
	(Acephate 90)	0.56-1.1 lb	0.5-1.0	
	aldicarb			
	(Temik 15G)	3.5 lbs	0.525	Apply Temik granules into the seed furrow at planting.
	thiamethoxam			
	(Cruiser)	Commercial seed	treatment	
	imidacloprid			
	(Gaucho Grande)	Commercial seed	treatment	
Thrips (seedling cotton), Foliar Spray	acephate			Apply when 2-3 thrips per plant are counted and immatures are present. Treatment is rarely necessary after plants have 4 true leaves and are growing vigorously.
	(Orthene 97)	3.0 ozs	0.18	
	(Orthene 90S)	3.2 ozs	0.18	
	(Acephate 97)	3.0 ozs	0.18	
	(Acephate 90)	3.2 ozs	0.18	
	dicrotophos			
	(Bidrin 8)	1.6-3.2 ozs	0.1-0.2	
	dimethoate			
	(Dimethoate 4)	0.25-0.5 pt	0.125-0.25	
Whitefly (banded winged)	acephate			Apply when 50% of terminals in rapidly growing cotton are infested, or when honeydew is found on foliage or lint of older cotton with open bolls.
	(Orthene 97)	0.5-1.0 lb	0.49-0.97	
	(Orthene 90S)	0.5-1.0 lb	0.45-0.9	
	(Acephate 97)	0.5-1.0 lb	0.49-0.97	
	(Acephate 90)	0.5-1.0 lb	0.45-0.9	
	thiamethoxam			
	(Centric 40 WG)	2 ozs	0.05	
Whitefly (silverleaf)	acetamiprid			Silverleaf whitefly is difficult to control with insecticides. Early detection and conservation of natural controls are important. Hairy leaf cottons are preferred by silverleaf whiteflies compared with smooth leaf varieties.
	(Assail 30 SG)	4.0-5.3 ozs	0.075-0.1	
	dinotefuron			
	(Venom 70WDG)	1-3 ozs.	0.045-0.134	
	fenpropathrin + acephate			Bifenthrin applied at high rates will suppress adults; tank-mixing with acephate will improve control.
	(Danitol 2.4 +	8-16 ozs +	0.15-0.3 +	
	Orthene 97)	8-16 ozs	0.5-1.0	
	pyriproxyfen			
	(Knack 0.86)	8 ozs	0.05375	
		5 ozs fb 5 ozs	0.033 fb 0.033	Vegetative cotton; 5 ozs. followed by 5 ozs.. See Label.
	spiromesifin			
	(Oberon 2)	8-16 ozs.	0.125-0.25	
	buprofezin			
	(Courier 40SC)	9-12.5 ozs.	0.25-0.35	

Premixed or Co-Packaged Insecticide Products:

Products listed below are available as premixes or co-packages of two insecticidal active ingredients. When using premixed or co-packaged products, be sure the use of all active ingredients is necessary. Unnecessary applications or use or reduced rates of an active ingredient may lead to or intensify insecticide resistance.

bifenthrin, avermectin B1 (Athena)

bifenthrin/imidacloprid (Brigadier)	flubendiomide/buprofezin (Tourismo)	lambda-cyhalothrin/chlorantraniliprole (Besiege)
dicrotophos/bifenthrin (Bidrin XP II)	imidacloprid/cyfluthrin (Leverage)	zeta-cypermethrin/bifenthrin (Hero)
lambda-cyhalothrin/thiamethoxam (Endigo)	spinosad/gamma-cyhalothrin (Consero)	chlorpyrifos/lambda-cyhalothrin (Cobalt Advanced)

COTTON DISEASE AND NEMATODE MANAGEMENT

Note 1 from 2011: As in 2010, most, if not all, of the cotton crop across the Coastal Plain was affected last season by leaf spots that often affected not only the foliage, but the bracts and bolls as well. In mild cases the diseased spots were a curiosity in the field; in severe cases complete defoliation occurred across large areas of a field. Extreme heat and drought across Georgia greatly increased the symptoms of Stemphylium leaf spot, a disease which is closely tied to a deficiency of potassium in the cotton foliage. Rapid, near complete defoliation in specific areas of a field is typically associated with Stemphylium leaf spot. A general, more gradual defoliation of the bottom 2/3s of the canopy is more likely associated with Corynespora leaf spot which does not seem to be a nutrient deficiency in the plant. To date it has been very difficult to consistently find any benefit from the use of foliar-applied fungicides for the control of Stemphylium leaf spot. In 2010, county agent RJ Byrne in Thomas County conducted a replicated fungicide study using a single application of Headline at 6.0 fl oz/A applied approximately two weeks after first bloom. Corynespora leaf spot was the primary disease in the field; the fungicide treatment not only significantly reduced pre-mature defoliation and the severity of the leaf spot but also numerically increased yields by an average of 63 pounds of lint per acre. Such results offer promise that we may soon have a recommendation for a specific disease that has plagued growers, consultants, and agents for years in southern Georgia.

Multiple field trials were conducted across Georgia in 2011 to assess the impact of Headline (pyraclostrobin) and Twinline (pyraclostrobin + metconazole) for management of foliar diseases of cotton. Although severe in a number of fields, the overall importance of Corynespora leaf spot last season was less than in 2010. This was almost certainly linked to environmental conditions (hot and dry) that were unfavorable for development of foliar disease. The results of the trials were mixed- where Corynespora was observed, it was often possible to observe a reduction in disease in plots treated with a fungicide. In other cases, especially where disease pressure was light, it was difficult to see any benefit from a fungicide application. The conditions that occurred in 2011 and the results from the field trials offer further evidence that not every field of cotton in the state will respond to fungicides with increased yields every season. However, it is also believed that use of fungicides where appropriate will become a useful tool for our cotton producers. **IT IS CURRENTLY UNCLEAR IF SOME VARIETIES ARE MORE SUSCEPTIBLE T CORYNESPORA LEAF SPOT THAN ARE OTHERS… thought his may be the case. Research continues…..**

Below are questions commonly asked last season about leaf spots on cotton:

Question 1. What is causing the leaf spots?
Answer 1. There were two factors that seem linked to recent outbreaks of leaf spots. First, an important factor last season was a link between weather conditions and potassium nutrition in the cotton plant. Insufficient potassium leads to weakened cell walls in the leaves that are more easily breached by fungal pathogens. The second factor, extended periods of wet weather, created conditions very favorable for development and spread of fungal diseases in 2009; drier weather in 2011 reduced the importance of some diseases

A. Stemphylium leaf spot (most common by far, linked to nutrient deficiencies)
B. Alternaria leaf spot (fairly common, sister disease to Stemphylium leaf spot, also linked to nutrient deficiencies)
C. Cercospora leaf spot (fairly common, also linked to stress and nutrient deficiencies)

D. Corynespora leaf spot (newly identified in Georgia, aggressive in 2009 and 2010, less important in 2011 because of weather, unrelated to nutrient deficiencies.)
E. Ascochyta wet weather blight (not observed in 2011).
F. Angular leaf spot, caused by a bacterial pathogen, was observed in some fields in 2011 but was not of significant importance..

Question 2. Will the build-up of fungal spores in a field (especially *Corynespora* sp. and *Stemphylium* sp.) predispose the same field to problems in 2012?
Answer 2. Although the spores will likely survive until next season amongst the leaf litter and debris, I don't feel that this inoculum will greatly increase chances of severe outbreak of Stemphylium leaf spot in 2012. The deciding factor for this disease will be the weather that occurs in 2012. However, outbreaks of Stemphylium leaf spot are historically more common in some fields than in others and in some regions of the state than in other regions. However, I am concerned that spores of *Corynespora* could lead to more severe infections in fields where a) the disease was a problem in the past, b) the field is planted using reduced/conservation tillage, c) cotton is planted behind cotton in rotation, and d) weather conditions are wetter than in 2011. If our fields experience frequent rains in 2012 and/or if potassium levels are low in the cotton plants, we will likely see another severe outbreak of disease; if not, we will likely not have so much disease.

Question 3. What will be the impact of the spots that spread from the leaves to the bracts and the bolls?
Answer 3. Three of the pathogens linked to the leaf spots this year (e.g. *Stemphylium*, *Alternaria*, and *Cercospora*) are NOT boll rot pathogens and at best create superficial blemishes on the cotton bolls. However, under the right conditions (i.e. high rainfall or canopy moisture) it is possible that these superficial wounds could be colonized and exploited by more aggressive pathogens resulting in boll rot. The fourth pathogen, *Corynespora* sp., has been linked to boll rots elsewhere in the world. The fifth, the bacterial pathogen *Xanthomonas campestris* pv *malvacearum*, was found to cause boll rots in Turner and Ben Hill Counties in 2010.

Question 4. How can Headline, Twinline or Quadris be used to control the foliar diseases we have seen this season?
Answer 4. Headline and Quadris are very effective fungicides and may indeed be shown to play a role in management of Corynespora leaf spot in the future. We continue to assess the use of Twinline as we have much less data for this mixture of pyraclostrobin and metconazole than we have for pyraclostrobin alone. It is unclear whether a fungicide, no matter how good a fungicide, can have a significant impact on a disease whose cause is an underlying nutritional problem (Stemphylium, Cercospora, and Alternaria leaf spot diseases). Also, even if a fungicide is effective to one degree or another, it MUST be in place to protect the crop before the disease becomes widespread in a field. Therefore, growers should consider the following:
A. If disease that is linked to a nutritional problem, such as Stemphylium leaf spot, occurs in a field, a fungicide is unlikely to provide effective control.
B. In the case of Corynespora leaf spot, there is data to demonstrate that a fungicide treatment can reduce disease and defoliation and also increase yields. This is, obviously, most likely the case where the severity of Corynespora leaf spot is severe. Corynespora leaf spot is likely to be most severe during periods of extended wet weather.
C. If a grower wants to test the efficacy of a fungicide, I STRONGLY advise leaving untreated areas in the field with which to compare disease control and yield to areas that have been treated.

D. If a grower wants to test efficacy, he should make a fungicide application BEFORE disease becomes established in the field and be prepared to follow with additional applications within 2-3 weeks after initial application.
E. Once disease becomes widespread in the field, it is unlikely that a fungicide would have any efficacy at all and the grower would be better served to save this money and use it elsewhere.

Question 5. What about applying a foliar fertilizer to improve nutrition in the leaves in order to control disease?
Answer 5. I will let our soil scientist address this; however I believe that IF a foliar application of fertilizer could ELIMINATE or greatly reduce the nutritional deficit before disease occurs, then it might be a viable management strategy. Otherwise, the foliar fertilizer would likely have no benefit in disease control.

Note 2 from 2011: Nematode management Yield losses associated with damage from plant parasitic nematodes was common across cotton fields again in 2011. Several important lessons should be mentioned, not the least of which was the sudden loss of aldicarb (Temik 15G).

A. From limited trials with varieties **Phytogen 367 WRF**, **Stoneville 5458B2RF**, and **Stoneville 4288B2F**, we finally have several cotton varieties with a measurable level of resistance to **southern root-knot nematodes** (there is no benefit on reniform or Columbia lance nematodes1). (Although the seed companies refer to this partial-resistance as "tolerance", it truly is "resistance".) In a trial conducted in Tifton in 2010, the end-of-season damage associated with PHY 367 WRF (galling) was much less severe and yields were significantly increased versus a competitive variety. Trials in 2011 offered further impressive results for the resistance found in PHY 367 and also for the Stoneville varieties as well. This is great news for our growers, especially with the loss of Temik!
B. With the loss of Temik 15G, I believe that use of Telone II will become more common among our cotton growers, especially if the supply of Telone can be stabilized. Also, there continues to be a move by some growers and consultants to develop "risk management zones" within a commercial field which could be treated with different rates and/or types of nematicides based upon threat from parasitic nematodes. In such a way, use of Telone II is reserved for areas that are most likely to need the extra "power" of this fumigant. Results from studies conducted in 2011 offer further evidence as to the benefits from use of Telone and the potential for site-specific applications.
C. **Loss of Temik 15G came as an unexpected and unwanted surprise to many growers last season.** Although there is still some Temik available from some distributors, our supply is now nearly depleted. There is talk that another aldicarb product may be imported from China in the future; however that is not going to happen for the 2012 season and may never happen. Below are UGA recommendations for management of nematodes on cotton in the absence of Temik 15G.
    a. In the absence of Temik 15G, it is hoped that growers who have resisted adoption of fumigation with Telone II at 3 gal/A will consider doing so now. Certainly there are costs associated with use of Telone II; however no product currently available in cotton production offers the same level of protection against all parasitic nematodes affecting the crop. Additionally, Dow AgroSciences had obtained a label for the at-plant application of Telone II when environmental conditions are favorable and the company is also working to develop variable-rate strategies and risk management zones where fumigation only occurs where

nematode populations warrant the treatment. In difficult situations, fumigation with Telone II provides significantly better control of nematodes than does Temik 15G. Growers who fumigate with Telone II must remember that this product can provide excellent control of nematodes but does not control thrips.

b. In addition to Telone II and Temik 15G, cotton growers in Georgia also can use seed-treatment nematicides AVICTA Complete Cotton from Syngenta, AERIS Seed-Applied System from Bayer CropScience, and Accelron N from Monsanto for control nematodes. AVICTA Complete Cotton and Accelron N both contain abamectin (Avicta) and thiomethoxam (Cruiser); however the Syngenta product uses azoxystrobin (Abound or Quadris) for additional seedling disease control whole Monsanto uses pyraclostrobin (Headline) for additional seedling disease control.
c. Although I have not tested Acceleron N or pyraclostrobin for use as cotton seed treatments, I have tested AVICTA Complete Cotton and AERIS Seed-Applied System. In my studies, at lower nematode populations, both AVICTA and AERIS can be comparable in efficacy to Temik 15G at 5 lb/A for management of nematodes. As nematode populations increase, Temik 15G, 5 lb/A provided better early season management of southern root-knot nematodes and increased yields over the seed treatments. From these studies, both AVICTA and AERIS can be used effectively in the management of nematodes, but not with the same spectrum of activity that Temik 15G, 5 lb/A, had. Though I have more experience with AVICTA Complete Cotton than with AERIS Seed-Applied System, in comparative studies the products have performed similarly. Note: Use of a post emergent application of Vydate CLV (17.0 fl oz/A) may help in the management of nematodes and thrips when used to compliment a seed treatment.
d. For management of plant-parasitic nematodes, rotate fields with non-host crops.
e. Where southern root-knot nematodes are a problem, consider planting PHY 367WRF, ST 5458B2RF, of ST4288B2F; also consider using a seed-treatment nematicide in conjunction with these varieties to further improve control of nematodes.
f. Use what Temik 15G is available in areas with more damaging nematode populations and save seed treatment nematicides for other areas.
g. Talk with representatives from DuPont to learn how VYDATE CLV (17.0 fl oz/A) may be used in conjunction with Temik 15G and seed-treatment nematicides for additional management of nematodes and thrips.

Diseases and Nematodes in Cotton

The importance of diseases and nematodes in cotton production is easy to overlook since the cotton plant is less severely affected by disease than are other crops and symptoms caused by nematodes can be easily misdiagnosed. However, it is estimated that in 2006 diseases and nematodes cost cotton growers in Georgia approximately $194 million. This figure includes the cost of control for the grower (mainly nematicides and fungicides for seedling disease) and losses to boll rot, nematodes, seedling diseases, and Fusarium wilt.

Many growers may not even recognize the price that they are currently paying to reduce disease. For example, the cost of basic fungicide seed treatments is included with the price of their seed, and growers may plant at an increased seeding rate, in part to off set potential losses from a poor stand due to seedling disease.

With the exception of losses to nematodes and seedling disease, the use of pesticides has not been economically justified to control most diseases of cotton in Georgia. (Note: This may change with the introduction of newer fungicides for control of foliar diseases as discussed above.) However, a grower can effectively reduce the impact of diseases and nematodes on his crop by making sound management decisions. These include the use of crop rotation, choice of planting date, fertility and plant growth management, and choice of cotton variety. Although difficult for some growers, good crop rotation with crops that are non-host for major cotton pathogens remains one of the most effective means of reducing losses in cotton.

Seedling Diseases

Seedling diseases are widespread but typically not a major problem in Georgia cotton in most years. However, economic loss to seedling diseases can be significant at specific locations, especially when weather conditions are cool and wet at planting time and the grower is not able practice good crop rotation. Seedling diseases are caused by fungi that either survive on the seed or that live in the soil and infect seeds or developing seedlings. By far, the most common cause of seedling disease in Georgia is the fungus *Rhizoctonia solani*; however *Pythium* spp. and *Fusarium* spp. May also damage young plants. Generally as the young plant matures it becomes less susceptible to infection by these pathogens.

Seedling diseases are differentiated by the stage of development of the seed and young plant when symptoms occur.

1. **Seed rot** is the first disease in this sequence and is easily identified by the presence of decayed seed; however the problem is often detected only after the grower notices "skips" in the stand. Seed rot may be caused a number of different fungi that can exist either in the soil or on the seed itself.
2. The second disease in this sequence is **pre-emergence damping-off** where a fungal pathogen attacks the young seedling after germination but before it cracks the soil surface. Like seed rot, pre-emergence damping-off results in skips in the stand.
3. **Post-emergence damping-off** occurs once the seedling has emerged from the soil. It is identified by the presence of a brown lesion at, or just below, the soil line that will eventually expand and girdle the young, succulent stem. Once the stem is completely girdled, the young plant will quickly wither and die. In the case of "hill-dropped" cotton, it is a common that if one seedling in a hill is diseased, all of the seedlings will be affected. Post-emergence damping-off is often referred to as "soreshin" in Georgia and is caused by the fungus *Rhizoctonia solani*. It is perhaps the most common seedling disease of cotton in the state and the one with which growers are most familiar. Although seedling disease caused by *Pythium* spp. is less common, it still occurs and is characterized primarily by a water-soaked root rot, either before or after emergence. As will be discussed later, it is important to identify the pathogen(s) that is/are responsible for seedling disease in a field as *Rhizoctonia solani* and *Pythium* spp. may not be controlled by a single fungicide

Management of Seedling Diseases

Control of seedling diseases of cotton begins with the use of a fungicide seed treatment. All commercial seed sold in Georgia is pre-treated with at least two fungicides. **Growers should never plant cotton seed that has not been treated with a fungicide**. Some seed treatments, such as thiram and captan, are protectant fungicides that protect the seed from fungi borne on the seed or in the soil associated with the seed. Other treatments such as Vitavax (carboxin), baytan,

metalaxyl (Allegiance), and mefenoxam (Ridomil Gold) have systemic activity and when absorbed in the seedling, offer some protection immediately following germination.

Growers can greatly minimize the effect of seedling diseases by avoiding conditions in which seeds/seedlings are at risk to damage from fungal pathogens. Cool, wet weather at planting and low soil temperatures produce an environment that not only slows germination and emergence, but may also favor fungal growth and infection. *Pythium* can be especially troublesome in saturated soils; *Rhizoctonia solani* is less dependent on soil moisture or temperature. **NOTE: Growers should avoid planting cotton seed when rain and colder soil temperatures are likely, even if seedling disease is not an issue.**

Rapid germination and vigorous growth by the seedling are factors which help to insure the survival of the young plants. Slower growth early in the season gives the fungal pathogens more time to infect the vulnerable seed and seedling. The sooner the seedling develops hard, "woody" tissue, the less likely it is to be penetrated and rotted by fungi. Good management practices to reduce the chance of disease include the following:

1. Plant in warm soils where the temperature at a 4-inch depth is above 65° F and where the 5-day forecast doesn't call for cooler or cooler/wetter weather. **NOTE:** Cotton growers should **NOT** plant cotton if at all possible when conditions are cool and wet or if the forecast calls for such conditions soon after planting, even if they plan to use additional fungicide treatments!
2. Plant seed on a raised bed since soil temperatures in the bed are generally slightly warmer than surrounding soil and drainage is likely to be better. Cotton planted in conservation tillage is not grown on raised beds, thus potentially increasing the threat from seedling disease.
3. Avoid planting seed too deeply. Seed that is planted too deeply results in longer periods before the young seedling cracks the soil surface, increasing the likelihood of seedling disease.
4. Correct soil pH with lime (pathogenic fungi are more tolerant to acidic soils than are cotton seedlings; pH should be in the range of 6.0 to 6.5).
5. Fertilize according to a soil test so as to promote rapid seedling growth; however care should be taken to avoid "burning" the seedling with excessive rates of at-plant fertilizers.
6. Avoid chemical injury through the use of excessive amounts or improper application of insecticides, fungicides, or pre-plant herbicides.
7. Plant only high quality seed as indicated by the percent germination in the standard seed and cool germination tests. Preferably, cool germination test results should be above 70%, though 60-69% is still adequate.

Additional seed treatment fungicides such as Dynasty CST, Trilex advanced, and Accelron, beyond the "base" treatment can significantly reduce the amount of seedling disease, increase stands, and potentially improve final yields where conditions are favorable for disease development. However, significant outbreaks of seedling diseases are a sporadic problem. Because we cannot reliably predict which years will have greater amounts of seedling disease, growers can become justifiably frustrated when trying to determine the economic benefit of the additional fungicide.

As significant yield losses to seedling disease are sporadic in Georgia, the Cooperative Extension does not recommend an additional fungicide treatment for each and every cotton field. Numerous field trials have been conducted by researchers at The University of Georgia assessing the benefits of seed treatments, hopper box treatments, and in-furrow fungicides. It has been very difficult to document significant yield benefits from these products despite increases in stand that may occur.

When a grower is assessing the need for additional protection from seedling diseases, he should note the following.

1. Any field with a history of cotton seedling diseases should be considered a prime candidate for the use of these additional fungicides and seed treatments.
2. This is especially true when a poor history is combined with any combination of the following: a. cool, wet weather at planting, b. poor seed quality, c. conservation tillage (which tends to keep the soil cooler and perhaps moister than conventional tillage), d. a low seeding rate, or e. the use of an in-furrow insecticide or nematicide. The risk for losses to seedling disease increases in fields where multiple factors, as described above, apply.

If a grower chooses to use a fungicide in addition to that already on the seed, he has the choice of additional seed treatments, a hopper box treatment, a granular in-furrow fungicide, or a liquid in-furrow fungicide.

8. Additional **seed treatments** are typically applied by the seed distributor or by a local distributor and may help to reduce the severity of seedling disease. In much of the research data collected from trials at The University of Georgia, the use of seed treatments in addition to those already sold with the seed did not improve yields. **However, given that some growers are lowering their seeding rates per acre in order to save on costs at planting, treating seed with an additional fungicide treatment may provide added protection to insure a successful stand.**
9. **Hopper box treatments** are perhaps the easiest for the grower to use as the fungicide, either a powder or liquid formulation, is mixed with the seed before planting. Hopper box treatments can be thought of as additional seed treatments and are most effective if mixed thoroughly with the seed. Unlike seed treatments, hopper box treatments frequently do not form a uniform coating on acid-delinted seed. Unlike in-furrow formulations, hopper box treatments are not well distributed in the soil that surrounds the seed and thus may not offer the same level of protection as an in-furrow fungicide.
10. **In-furrow fungicides** theoretically offer the grower protection that is beyond that of hopper box or additional seed treatments. There are basically of two types of in-furrow fungicides: granular and liquid formulations. Both formulations are applied to the open furrow as the seed is planted. Because of this, both the seed and the soil within the furrow are treated which helps to protect the seedling as it begins to grow. Growers, especially those who apply at-plant herbicides, may find it easier to use granular formulations for a couple of reasons. First, their equipment may not be set up to apply more than one liquid formulation (i.e. they only have a single tank). Second, many planters already have a split hopper where an insecticide/nematicide can be put in one half and the fungicide can be placed in the other. Calibration of granular fungicides is fairly simple but must be checked periodically to make sure that the correct amount of product is being applied. Although potentially more challenging to

apply, liquid formulations may offer the greatest protection against seedling disease because of the coverage in the open furrow. Whether a grower applies a liquid formulation with a single nozzle or with a dual nozzle set up, he should insure that not only the seed, but the soil beneath and around the seed are also treated. The University of Georgia Extension Bulletin 1143, "Cotton Diseases and Their Control," provides more detail on control practices.

Final note on seedling diseases: It is important to understand that fungicides which are effective on *Rhizoctonia solani* may not be effective on *Pythium* spp., and vice versa. For example, PCNB is active against *Rhizoctonia* but not *Pythium*. Metalaxyl, mefenoxam, and etridiazole are active on *Pythium* spp. but not *Rhizoctonia*. Appendix II includes detailed information on chemical treatments for seedling diseases.

Fusarium Wilt

Fusarium wilt is a fungal disease that typically becomes evident in mid-season, though it can occur at any point in the growing season. **In 2011, a severe outbreak of Fusarium wilt was observed in a field in Berrien County which was affected by sting nematodes**. Fusarium wilt is not currently a wide-spread problem in Georgia; however there are fields throughout the state where losses can be significant. For some reason, Fusarium wilt seems to be more common around Berrien County than elsewhere.

In cotton, Fusarium wilt is usually found in association with infections by the southern root-knot nematode, which has a synergistic effect on this disease. Although root-knot nematodes are most often associated with Fusarium wilt, other parasitic nematodes such as Columbia lance, reniform, and sting nematodes also injure cotton roots and increase the severity of the disease. As populations of parasitic nematodes increase throughout the state from inadequate crop rotation, it is possible that Fusarium wilt will become a more serious problem. Recommended control measures for this disease are to plant Fusarium wilt resistant cotton varieties (none is currently available) and to control root-knot and other nematode infestations.

The most visible symptom of Fusarium wilt is the presence of wilted and dying cotton plants in a field. Some plants may be stunted and the leaves may yellow between the veins (also know as interveinal chlorosis). Root-knot nematodes alone can cause wilting, but the synergistic effect with the Fusarium fungus is usually required to kill plants, unless the soil is extremely dry for prolonged periods. Fusarium-infected plants wilt even if soil moisture is adequate because of damage to the vascular system that carries water throughout the plant.

A preliminary diagnosis of Fusarium wilt can be made fairly easily in the field by slicing through the plant stem at a shallow angle to expose the vascular tissue. Fusarium wilt will cause a noticeable browning of the vascular tissue. This discoloration is the result of damage to the vascular tissue which prevents adequate flow of water and nutrients. If you **carefully dig** up the root system of wilting plants, you will also usually see significant galling caused by root-knot nematodes. To verify the diagnosis, submit a sample through your county agent to the UGA Plant Disease Clinic. You should also submit a soil sample for nematode assay to the UGA Extension Nematology Laboratory.

Plants affected by Fusarium wilt tend to be clustered in the field rather than randomly spaced. In

fact, areas of the field where Fusarium wilt occurs will probably be consistent from year to year. This is because the fungal pathogen and the associated parasitic nematodes tend to be unevenly distributed in the field. Additional information on Fusarium wilt in cotton can be found in University of Georgia Extension Bulletin 1143, "Cotton Diseases and Their Control." and "Cotton Nematodes and Fusarium Wilt", Leaflet L 82, 1996.

Nematodes

An estimated 60 to 70 percent of Georgia's cotton fields are infested with at least one species of potentially damaging nematodes. In a recent statewide survey of cotton fields (nearly 1800 samples were submitted by agents from randomly selected fields in 2002) approximately 69 percent of the fields were infested with root-knot nematodes, 2.8 percent with Columbia lance nematodes, 4.6 percent with reniform nematodes, and 0.6 percent with sting nematodes. While the southern root-knot nematode is responsible for the greatest amount of damage to cotton in the state, the Columbia lance and reniform nematodes also cause tremendous damage in more restricted areas, e.g. in the heavier soils along our the fall-line between the Piedmont and the Coastal Plain. Every cotton grower in the state of Georgia either has a problem with nematodes now or is at risk for such a problem should they lose the ability to practice effective crop rotation.

If damage to cotton from parasitic nematodes is such an important problem in Georgia, one may question why more attention is not devoted to this pest. There are three basic reasons. First, many growers do not recognize the symptoms of nematode damage as they can appear similar to drought stress, poor soil fertility, and injury from herbicides. Second, nematodes are microscopic worms that are not easily viewed by the growers. Third, many growers feel that they cannot afford to treat with nematicides because of the perceived cost associated with such treatments. Nothing could be further from the truth.

Symptoms of Nematode Damage

Symptoms of damage from nematodes in a field are variable and are dependent on the species of parasitic nematode infecting the plants. Damage from reniform nematodes may be evident in the seedling stage where severely infected plants wilt and die. Stunting throughout the season is the most readily recognized symptom of severe infection by root-knot, reniform, and Columbia lance nematodes. In some cases, stunting may approach 50%, and infected plants are likely to show drought stress earlier than healthy plants. However, plants infected with low levels of reniform nematode may actually grow taller and larger than healthy plants as nutrition is going to vegetative growth rather than filling bolls. Although foliar symptoms are not the direct result of infection by parasitic nematodes, infected plants often show nutrient deficiencies, e.g. nitrogen and potassium, in the leaves. The leaves may be slightly yellowed, and in more advanced cases, interveinal chlorosis and leaf scorch may occur.

It is often useful to examine the root systems of plants suspected to be infected with parasitic nematodes to further diagnose the problem. It is important to carefully dig and remove the roots from the soil to preserve the finer secondary roots; roots infected with root knot nematodes often develop swellings and galls that are most evident on the finer secondary roots. The galls can be fairly small, but are visible if the roots are examined carefully. The tap roots from plants infected with the Columbia lance nematode are often severely stunted because of feeding at the growing tip by the nematodes. Secondary roots are also often severely stunted. Root systems from plants infected with reniform nematodes may appear normal because this parasite does not produce galls

or severely stunted taproots. However, small clumps of dirt particles (containing egg masses) may be visible on the roots with the aid of a magnifying glass.

Crop Rotation

Crop rotation is a critical tool for nematode management in Georgia's cotton and should be used where economically feasible. Alternating cotton crops with non-host crops will help to reduce the size of the nematode populations in a field. Although this reduction may not be sufficient to eliminate the need of a nematicide in all fields, it will allow the grower to receive better effectiveness and larger yields from lower rates of nematicides.

Common rotation crops to help manage nematodes damaging to cotton include the following: peanut and certain forage crops for southern root-knot nematode; peanut, and certain forage and vegetable crops for Columbia lance nematode; peanut, corn, and certain forage and vegetable crops for reniform nematode. Corn is a host crop for several important species of root-knot nematode, but recent research documents that the root-knot species found in soil samples from corn fields will almost always be the southern root-knot nematode regardless of previous crop. Therefore, when planting cotton following corn, it should be assumed that any root-knot nematodes found in a soil sample from corn will also be damaging to the subsequent cotton crop. Additional information can be found in UGA Extension Bulletin 904 "Plant Susceptibility to Major Nematodes in Georgia."

Growers who practice conservation tillage often have questions regarding cover crops and nematode management. Common cover crops such as wheat, oats and rye are somewhat susceptible to the southern root-knot nematode. However, because nematodes are inactive during the winter months when soil temperatures are cold and because wheat, oats and rye are fairly poor hosts for the southern root-knot nematode, these cover crops can be planted without increasing the nematode problem in the next cotton crop.

Leguminous cover crops, such as clovers and vetches, are also popular in conservation tillage, especially with the current cost of nitrogen. However, growers who have problems with southern root-knot nematodes in a field should exercise caution in planting vetches or clovers as cover crops because they are very good hosts. Though cold soil temperatures in the winter will reduce the build-up of nematodes on clover and vetch, the nematodes will become active once the soil begins to warm up in the spring. Growers who wish to plant vetches or clovers in a field where southern root-knot nematodes are present should seek to find a resistant variety, if one exists.

Nematodes and Stress

Nematodes are considered "stress" pathogens because of the sub-lethal damage that they typically cause to the root system. In addition to crop rotation, one very effective way to reduce the effects of nematodes in a field is to reduce the stress on the cotton crop. Fertility, pH, hardpan and water problems exacerbate plant injury due to nematodes and should be corrected. Irrigation can reduce, but not eliminate, yield losses caused by nematodes. Growers should wash soil from equipment that is being moved from infested to non-infested fields in an attempt to minimize the spread of the parasitic nematodes. There are no commercially available varieties with acceptable levels of resistance to root-knot, reniform, or Columbia lance nematodes. However, the variety ST5599BR is reported to have some tolerance to the southern root-knot nematode. Tolerance is defined as the ability to produce acceptable cotton yields even in the presence of damaging

populations of the root-knot nematodes. Research continues at The University of Georgia to evaluate the performance of this variety in fields with elevated root-knot nematode populations.

Resistant Varieties

In the future, it may be possible for growers to select a cotton variety with resistance to parasitic nematodes for use in an appropriate field. Resistance varieties are probably the best long term solution to nematode problems. **Phytogen 367 WRF, ST 5458B2RF and ST 4288B2F** offer cotton growers a new opportunity to manage **southern root-knot nematodes** in Georgia.

Nematicides

Nematicides are an important component in the management of nematodes on cotton. Despite their effectiveness, nematicides cannot completely compensate for poor crop rotation. Recommendations to use a nematicide are usually based on the results of a nematode assay from a soil sample collected near harvest of the previous year's cotton crop. Nematicides, e.g. AVICTA Complete Cotton, AERIS Seed-Applied System, Temik 15G applied at "nematode rates", and Telone II, can provide cost-effective control of nematodes when yield losses are expected to exceed approximately 10% or when results from a soil sample exceed a predetermined economic threshold. The choice of one of these products over another is influenced by factors such as the potential severity of losses to nematodes in a field versus the level of control offered by the product, application capabilities of the grower, and cost. Although growers may be concerned about the initial cost of using a nematicide in a field with damaging populations of parasitic nematodes, the resulting increase in yield will often provide a very good return on the investment. Nematode threshold levels and nematicide options also are given in Appendices III and IV. Additional information can be found in UGA Extension Bulletin 1149 "Cotton Nematode Management," UGA Extension Circular 834 "Guide for Interpreting Nematode Assay Results," and UGA Extension Bulletin 1160 "Controlling Nematodes with Soil Fumigants."

Seed Treatments and Nematodes

Until recently, cotton growers in Georgia typically considered using Temik 15G, Telone II, and perhaps Vydate C-LV for managing nematodes. In 2009, growers will be able to use three seed treatments that have been promoted for the management of nematodes on cotton. These seed treatments are a) AVICTA Complete Pak from Syngenta, b) AERIS Seed-Applied System from Bayer Cropscience and c) N-Hibit, from Plant Health Care, Inc.

It is very important that growers understand that N-Hibit is a different type of product than AVICTA Complete Cotton and AERIS Seed Applied System. The nematicidal activities of AVICTA Complete Cotton and AERIS Seed-Seed Applied System have been assessed in a number of field trials and may reduce damage from parasitic nematodes and increase yields. To date, N-Hibit has been shown in a study at the University of Arkansas to reduce the egg production of root-knot nematodes on cotton roots in the laboratory. The benefit of this finding in the commercial field is unclear. However, in field trials conducted by the University of Georgia, the use of N-Hibit seed treatment coupled with an in-furrow application of Temik 15G (5 lb/A) has not improved yields over the use of 5 lb/A Temik alone.

AERIS Seed-Applied System is a product from Bayer Cropscience and includes a mixture of the active ingredient thiodicarb for nematode management and Gaucho (imidacloprid) for thrips control. An additional fungicide for control of seedling diseases is not automatically included

with AERIS Seed-Applied System (as it is in AVICTA Complete Cotton). However, an additional fungicide seed treatment (Trilex) may be added to AERIS if the grower feels such is needed. By keeping the addition of the fungicide optional for the grower, Bayer Cropscience is able to keep the cost of the key components- a nematicide and a thrips management insecticide, at a lower price.

The University of Georgia has less research data on AERIS Seed-Applied System than on AVICTA Complete Cotton. In data collected in 2006 and in 2007, the results obtained for AERIS Seed-Applied System + Trilex have been similar in most situations to AVICTA Complete Cotton. Growers who use AERIS Seed-Applied System in 2009 should only use it fields where there is low to moderate pressure from nematodes. AERIS Seed-Applied System will not provide sufficient control in fields with more damaging populations of plant-parasitic nematodes.

AVICTA Complete Cotton is composed of Avicta (abamectin) for management of nematodes, Cruiser (thiomethoxam), for early season thrips management, and Dynasty CST for additional protection from seedling disease. Growers who wish to use AVICTA Complete Pack can either pre-order the product with their seed or have it treated at special facilities after acquiring the seed. AVICTA Complete Pack is to be marketed as comparable in efficacy to 5.0 lb/A of Temik 15G. That is, Syngenta is confident that AVICTA Complete Pack will provide control of nematodes similar to that of Temik 15G at 5.0 lb/A.

Evaluations of AVICTA and AVICTA Complete Cotton began in field trials at The University of Georgia in 2003. AVICTA Complete Cotton does have efficacy against nematodes on cotton and that it can perform well in some situations. In the evaluations by the University of Georgia, there have been a number of trials where yields from AVICTA Complete Pak and Temik at 5.0 lb/A have been equivalent, and other trials where one product out yielded the other. The main concern for AVICTA Complete Cotton has been in the variability in the performance of this product.

After reviewing the data that has been collected for the nematicidal activity of AVICTA Complete Cotton and AERIS Seed-Applied System by the University of Georgia, it is evident that these seed treatments are a popular and valuable tool for growers. However, Temik 15G (5 lb/A) has efficacy at higher/more damaging populations of nematodes than do the seed treatment nematicides. This is based upon ratings of early season galling on the cotton roots and on final yields. Based upon the ease with which AVICTA Complete Cotton is used in the field, fewer growers are asking is, "Is AVICTA Complete Cotton (or AERIS Seed-Applied System) AS GOOD as Temik 15G (5 lb/A)?" and more are asking "Is AVICTA Complete Cotton GOOD ENOUGH for my field?".

Below are UGA recommendations for use of AVICTA Complete Cotton or AERIS Seed-Applied System.

11. Growers who want to try AVICTA Complete Cotton or AERIS Seed-Applied System in 2010 should ensure that the nematode levels in their field are low-to-moderate, e.g. less than twice the economic threshold value. Neither AERIS Seed-Applied System nor AVICTA Complete Cotton will offer the same protection that Telone II or Temik 15G (applied both at planting and at side-dress) offer. From data collected in 2006, use of AVICTA Complete Cotton or AERIS at planting **followed by** a timely side

dress application of Temik 15G (5 lb/A) looks to be a promising treatment in fields where nematode pressure is more severe, but is NOT as effective as applications of Telone II. (Obviously Temik 15G may not be available from now on.)

12. Growers who use AVICTA Complete Cotton or AERIS Seed-Applied System in Cotton are encouraged to conduct their own field tests; perhaps by treating a portion of their field with the seed treatment(s) and a portion of their field with Temik 15G at 5.0 lb/A.

More on Temik 15G and Telone II **(Recognizing that Temik may not be available.)**

Telone II is an extremely effective nematicide and can used economically even when nematode populations are not only "moderate-to-high" but also at times when the poulations are considered "low". Before using nematicides such as Temik and Telone, growers need to remember that they are Restricted Use Pesticides and misuse can be hazardous. Always consider your personal safety and the safety of those around you as the greatest priority. To obtain the greatest benefits from a nematicide, growers must consider the following:

1. Growers should ensure that they are using a product and a rate that is appropriate for the severity of nematodes in a field.
2. Application equipment must be properly calibrated to deliver precise rates of product. Lower than labeled rates may provide insufficient control while excessive rates are an unnecessary expense and may injure cotton. Calibration should be checked periodically throughout planting time to make sure that flow rate has not changed. Assistance with calibration is often available through the county agent and industry representatives.
3. Equipment used to deliver nematicides must be properly maintained and checked for leaks and plugged lines. For use of Temik, hopper boxes should be cleaned and inspected before adding the product. Drop tubes should not be cracked or damaged. Rotors should be clean and not too worn. If Temik is to be left in a hopper box overnight, the hopper box should be covered and the tubes plugged to protect from moisture. Flow meters and tubing may need to be cleaned with a substance such as diesel fuel after using Telone. For more detailed information, contact Temik and Telone representatives.
4. The effectiveness of Temik is influenced by soil moisture levels at the time of planting (for activation of the product and movement in the soil). Telone II is a fumigant and therefore not dependent on water for movement through the soil; however its effectiveness is still affected by both soil moisture (for proper soil sealing) and soil temperature (greater than 40 degrees F) at the time of application. Growers should make sure that conditions are adequate for maximum effectiveness of the products.
5. Growers who choose to side-dress with Temik 15G should be very conscientious of proper timing of the application. The purpose of the side-dress application is to improve nematode control by extending the protective window for the young cotton. Typically, the side-dress application is made somewhere between the 2nd and 8th true-leaf stages and prior to pin-head square. If the application is not applied in a timely manner, the grower will likely damage the roots of the young cotton as the product is knifed into the soil. This damage can result in reduced yields.
6. For many growers, the exposure and aeration period for use of Telone II is 7 to 14 days between application and planting. However, Telone II is labeled in Georgia for an at-plant application, i.e. the grower can apply Telone II and plant the cotton seed in

a single trip across the field. An at-plant application of Telone II will be particularly attractive to growers who use conservation tillage.

7. Although an at-plant application of Telone II can be accomplished successfully, under certain environmental conditions it can also lead to phytotoxicity, an increased risk of injury to seeds and seedling, and a reduction in germination. Before a grower chooses to apply Telone at-plant without waiting the standard time period, he should insure that heavy rains and cooler soil temperatures are not forecast soon after planting. He may also wish to consult the county agent and/or Telone dealer for further guidance.

Use of Vydate C-LV (oxamyl)

Vydate C-LV is an insecticide/nematicide that is applied as a foliar spray to cotton typically at 17.0 fl oz/A between the 5th and 8th true-leaf stage of cotton development. This application is a supplemental treatment for earlier applications of Telone II or Temik 15G, or use of AVICTA Complete Pak or AERIS Seed-Applied System. Use of Vydate C-LV is quite popular with cotton growers in the mid-south (e.g. Mississippi), but much less so in Georgia. For whatever reason, Vydate C-LV has rarely shown a yield benefit in our trials; however it is certainly an option for growers who seed additional protection from nematodes after cotton seedlings emerge.

Examples of Use of Nematicides based on Soil Samples

Extension Specialists and County Agents are often asked to recommend treatments for a cotton crop based upon the results from a soil sample collected in the fall of the previous season. This can be very difficult to do. For example, high populations of nematodes may cause tremendous damage in one field, but only minor damage in a field with ideal growing conditions. Conversely, low populations of nematodes may not cause any damage in one field, but cause serious damage in another field suffering from drought or fertility stress.

There are no hard-and-fast rules on recommendations for use of nematicides; however options based upon results from recent field trials are presented below. In general, where any parasitic nematodes are found in a cotton field, Temik 15G (3.5 lb/A) is preferential over either Cruiser or Gaucho seed treatments as there tends to be some yield benefit, even though 3.5 lb/A provides minimal control of nematodes. As the size of the nematode populations increases a grower may consider the use of AERIS Seed-Applied System or AVICTA Complete Pak, or increase the rate of Temik 15G from 3.5 lb/A to 5-6 lb/A to 7 lb/A (note caution below). Also, side-dress applications with Temik or foliar applications of Vydate C-LV can be effective as well. In particularly troublesome fields, and where populations of nematodes are high, use of Telone II provides the most consistent management of the nematodes. Specific examples are presented below.

1. **No nematodes** are identified in a soil sample collected in the fall: Grower should use Temik (3.5 lb/A), or Cruiser or Gaucho Grande seed treatments for the management of thrips.
2. **Low levels of parasitic nematodes (well below threshold values) are identified in a soil sample collected during the fall:** Grower should consider using Temik at 3.5 lb/A. Results from research trials consistently demonstrate that Temik 15G, even at a "thrips" rate of 3.5 lb/A, provides some benefit in a field infested with low levels of nematodes above Cruiser or Gaucho Grande. In fields where nematode damage has been observed in the past, despite apparently low levels of plant parasitic nematodes,

growers may consider use of higher rates of Temik 15G, AVICTA Complete Cotton, or AERIS Seed-Applied System.

3. **Levels of parasitic nematodes in a fall sample approach, match, or are slightly above threshold values for parasitic nematodes:** Grower should consider, as a minimum, the use of Temik 15G at 5 lb/A, AVICTA Complete Cotton or AERIS Seed-Applied System.
4. **Levels of parasitic nematodes exceed threshold values (e.g. 2X threshold values) in the fall and damage has been observed:** Although growers may still obtain sufficient control with AVICTA Complete Cotton or AERIS Seed Applied System, Temik 15G, 5.0 lb/A has been shown to provide better early-season control of nematodes on cotton. Additionally, growers may also consider the 5 lb/A at-plant rate of Temik 15G (or perhaps use of AVICTA Complete Pak) and then later side-dress with either Vydate CLV (17 fl oz/A 2nd to 6th true leaf stage), or another application of Temik 15 G at 5 lb/A prior to pinhead square. Side-dress applications of Temik will provide more consistent results than with Vydate, especially in heavily infested fields. If the grower chooses not to side-dress, he may consider an at-plant application of Temik 15G at 7 lb/A. **However, this rate (7 lb/A) has been observed to reduce yields below those achieved with 5 lb/A in some trials; hence it should be used with caution. Note: Telone II may also provide excellent results in this category as well.**
5. **Levels of parasitic nematodes in the fall soil samples are well above the economic threshold, or combinations of nematodes each reach threshold values:** In such situations, the grower should consider using either the 5 lb/A + 5 lb/A side-dress Temik option or using Telone II at 3 gal/A (pre-plant) + a product for thrips control. In the case where the problem in the field is associated specifically with the Columbia lance nematode, use of Telone II may be the better option as this nematode can be difficult to manage.
6. **Levels of parasitic nematodes in the fall samples are much greater than the economic threshold values and damage from nematodes has been significant in the past:** Grower may still achieve satisfactory results with a 5 lb/A + 5 lb/A side-dress Temik option; however at such elevated nematode populations (and beyond) use of Telone II is often the most effective and consistent treatment.

Development of Risk Management Zones as a tool for nematode management in cotton.

Plant parasitic nematodes, especially root-knot nematodes, are often unevenly distributed across a field. Because of this "patchy" distribution, the damage attributable to nematodes in a cotton field is often highly variable from one point to another. Much of this variation is the result of differences in the characteristics of the soil.

Accurate identification of different risk zones in a field should be attractive to cotton producers. If growers can determine risk zones across a field based initially on soil type (measured indirectly through the use of soil electroconductivity values) and subsequent sampling for nematodes, then they can use this information to refine use of nematicides in a field. For example, in areas of the field where risk to nematodes is more severe, then growers may choose to use more effective, but more expensive, treatments such as fumigation with Telone II. Where risk to nematodes is known to be reduced, growers may choose to use a product like Temik 15G or even nematicide seed treatments.

Growers who are interested in developing risk management zones for nematodes in their fields should consider the points listed below:

1. Southern root-knot nematodes are the key plant parasitic nematode affecting cotton in much of Georgia.
2. Southern root-knot nematodes are often unevenly distributed in a field; largely as a factor of soil type.
3. Populations of southern root-knot nematodes tend to be proportional to the percentage of sand in the soil in a field. Larger percentages of sand often support higher levels of nematodes; higher percentages of silt and clay (heavier soils) tend to have smaller populations of southern root-knot nematodes.
4. Southern root-knot nematodes tend to prefer the interstitial spaces of sands (spaces between sand particles) for ease of movement in the soil.
5. Risk management zones for management of southern root-knot nematodes are currently being studied and developed in a number of states, to include Georgia, South Carolina, and Louisiana.
6. In Georgia, Risk Management Zones are developed largely on the use of VERIS rigs that map soil conductivity in a field. Higher soil electrical conductivity (EC) indicates more silt and clay and less sand. Lower soil EC values indicates more sand.
7. Maps can then be drawn to split the field into zones with higher EC values and lower EC values.
8. The OPTIMIUM use of these maps is to focus nematode sampling efforts to confirm populations in higher risk zones and lower risk zones. It is NOT sufficient to simply determine choice of nematicide based upon soil EC maps.
9. Remember: Soil EC values indicate the possibility for different populations of nematodes but not necessarily the reality. For example, there are certainly very sandy fields in the state that have few if any southern root-knot nematodes, often because of great crop rotation. In other fields a grower may be able to define Risk Management Zones based upon soil EC; however the differences in EC may not be of biological significance and the entire field would benefit from a nematicide like Telone II (hence the need to take nematode samples.)
10. Finally, even though there may be Risk Management Zones in a field appropriate to treat with different rate/nematicides based upon nematode samples, there may also be OTHER agronomic factors (e.g. fertility, moisture retention, etc) that may keep zones from yielding as hoped.
11. FINALLY: I truly believe that when used appropriately, risk management zones ARE a very important tool for the best cost-effective management of nematodes in Georgia.

Boll Rot

Boll rots are caused by a complex of fungal and bacterial pathogens. Boll rot is unavoidable if cotton is subjected to prolonged periods of wetness and humidity late in the growing season. In Georgia, this can happen if a tropical storm or hurricane causes excessive rainfall, especially over a several-day period. In such situations, there is little a farmer can do to minimize losses to boll rots.

Actions that reduce humidity in the cotton canopy can help reduce the likelihood of a significant boll rot problem in the absence of inclement weather. Such practices include proper nitrogen fertilization to avoid rank vegetative growth, lower plant populations (plants/acre), timely defoliation and harvest, and the use of mepiquat chloride, a plant growth regulator which limits vegetative growth. These practices increase airflow through the canopy and reduce humidity around the lower bolls which makes the microclimate less conducive for boll rots. Adjusting planting dates so that bolls approach maturity later in the summer, when conditions are typically drier, can help. Neither fungicides nor bottom defoliation have proven effective for boll rot control. Plants with fewer bolls may have increased vegetative growth, which can increase humidity in the plant canopy thereby increasing boll rot problems. For additional information, refer to UGA Extension Leaflet 143, "Cotton Boll Rot." Good insect control can reduce boll rot. Injury from insect feeding can increase boll rot by creating wounds where rot-inducing organisms can enter bolls and by causing plants to set fewer bolls. Also, proper insect control can promote better plant utilization of nitrogen, thus reducing excessive vegetative growth.

Fusarium Hardlock of Cotton

Every grower in the state is aware that his field will contain bolls with lint that does not "fluff", a condition that has been referred to as "tight-lock" and "hard-lock". Such bolls are usually not harvested with a spindle-type picker. Reasons for the failure of the boll to fluff properly include boll rots, insect damage (especially from stink bugs), environmental conditions at boll opening (e.g. very high humidity), immature bolls, and perhaps other factors. Researchers in Florida have been evaluating this problem in considerable depth over the past several years and have concluded that the fungus *Fusarium verticillioides* is a causal agent of at least some of the hardlock of cotton in that state. They have differentiated this condition as "Fusarium hardlock" and theorize that the infection by the fungus occurs through the flower at bloom, rather than directly through the boll as in traditional boll rot. They have also reported that multiple applications of specific fungicides have been helpful in the management of Fusarium hardlock. Research results from across the Southeast in 2003, 2004, and 2005 have not adequately demonstrated the benefits of fungicide applications to manage Fusarium hardlock. At this point, researchers in Georgia are uncertain of the benefit of fungicide applications to manage hardlock, the timing and frequency of such applications, or the rate of such. No fungicides are currently labeled for the management of "Fusarium hardlock" in Georgia. For the 2009 season there is no recommendation for the use of a fungicide to manage Fusarium hardlock.

Foliar Diseases

Although cotton is susceptible to a number of diseases that affect the leaves, they are not usually a problem in Georgia and tend to show up most often on aged and senescent tissue. Cotton foliage is often marred by various leaf spots caused by fungi such as *Cercospora*, *Alternaria*, and *Ascochyta*; yet no control measures are generally needed. Ascochyta wet weather blight was very common in 2003 due to the ample rainfall. However, the disease was typically gone early in the season and no treatment was necessary.

In 2009, Corynespora leaf spot was frequently observed and significant defoliation due to this disease was observed in a number of counties. Corynespora leaf spot on cotton was first documented in Mississippi and has been linked to yield losses and even boll rots in some areas of the world. It is unclear at this time how important this disease will be in Georgia or in the United States.

Late season outbreaks of Ascochyta blight in 2005 and 2006, especially in southwestern Georgia, caused great concern for a number of growers, agents, and crop consultants. Spots from this disease developed extensively on the petioles, foliage, and bolls of affected cotton plants. Fortunately, most of this damage seemed to be superficial and did not cause serious losses; however, Headline (pyraclostrobin) and Quadris (azoxystrobin) are now labeled for control of this disease.

Over several seasons, growers and agents have noted a disease resembling powdery mildew in the field. This disease is likely to be "aereolate mildew" and is caused by the fungus *Ramularia*. Yield losses are generally not attributed to this disease. In 2007, foliar applications of Headline (6.0 fl oz/A) and Quadris (9.2 fl oz/A) provided outstanding control of this disease.

Perhaps the most troubling foliage concern for growers is known as Stemphylium leaf spot because of the lesions produced by the fungal pathogen. Interestingly, although the fungus *Stemphylium* spp. is the cause of the disease, it is the occurrence of late-season potassium (K) deficiency that predisposes the foliage to infection by the pathogen. Potassium adds strength to the cells in the plant leaf; it is the deficiency of K that makes the leaves susceptible to infection by *Stemphylium*. What begins as well formed leaf spots can in severe cases lead to complete defoliation soon after the fourth week of bloom. The use of fungicides will not correct the problem. To prevent Stemphylium leaf spot, growers should insure that adequate K is available in the soil through careful soil testing and proper fertilization.

Management of foliar disease: Headline (pyraclostrobin) and Quadris (azoxystrobin) are now labeled for use on cotton to manage foliar diseases. Although additional studies are needed to document the yield advantage from use of this product, results from 2007 CLEARLY demonstrate its efficacy on Aereolate mildew and Ascochyta blight. However, it is still unclear whether or not applications of Headline or Quadris will be beneficial in the management of Stemphylium leaf spot, Cercospora leaf spot, or Corynespora leaf spot, or if the application of fungicide will lead to increases in yield.

If a grower decides to use a fungicide to manage foliar disease of cotton, then he must consider a) optimal timing of application and b) number of applications that should be applied.

Seed Rot: This malady was first detected in Hampton County, South Carolina, in July 1999. To quote a report from South Carolina, "Seed rot was observed in apparently healthy fields which had high yield potentials 3 to 4 weeks after initiation of flowering. Bolls containing seed rot exhibited no outward symptoms of seed rot or any other problem. Symptoms were most visible when bolls were cut transversely. Affected seeds were poorly developed and often hollow, while less affected seeds were pinkish in color and partially hollow...Bolls in which seed rot occurred did not mature normally and were often hard- or tight-locked, i.e. unharvestable by mechanical picker." (From: "Preliminary investigations on cotton seed rot in South Carolina", Clemson University Station Bulletin 675, September 2000). The definite cause of this problem has not been determined by researchers in South Carolina and their efforts on this issue continue. Although symptoms similar to "seed rot" have been reported by agents in Georgia, our state does not seem to have the severity of the problem as South Carolina. Growers who detect this problem in their fields should report it to their local county agent.

Bronze Wilt

Bronze wilt is a plant malady that affected thousands of acres of Georgia's cotton in 1998 but has been quite limited in subsequent crops. Bronze wilt has thus far been limited to varieties that have TAMCOT SP-37 in their pedigree. These include Stoneville 132 and 373, the Paymaster 1200 series, and a few transgenic lines in which a Paymaster 1200 parent was used as the donor of Bollgard and Roundup Ready genes.

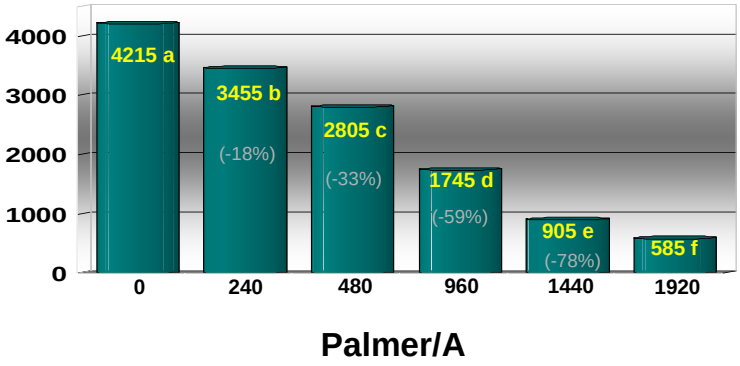
Bronze wilt is related to restricted water transport in the plant and manifests itself with numerous symptoms. These include reddish bronze discoloration in the upper canopy, elevated leaf temperatures, extreme reddening of plant stems, and/or loss of fruit and foliage. In young plants, initial pale coloration can progress to total plant death. Bronze wilt is more easily diagnosed in younger plants that begin to redden and wilt than in mature plants with heavy fruit loads. Older plants with heavy boll loads are more susceptible to stresses that produce nearly identical symptoms that are unrelated to bronze wilt. Conditions that may be confused with bronze wilt include premature cutout, normal plant maturation and senescence, nutrient depletion, Fusarium and Verticillium wilts, and environmental stresses.

Bronze wilt is triggered in part by an interaction between the genetics of the cotton variety and hot weather. Since bronze wilt is not a true disease, the isolation of a pathogen is not involved in the diagnosis of this condition. Therefore, diagnosis of bronze wilt is often made after ruling out other possible causes of plant decline. **Bronze wilt is successfully controlled by avoidance**; that is by NOT planting varieties with the genetic background known to have potential for the problem. Also, bronze wilt has been found to be less severe when susceptible varieties are planted earlier in the season rather than later.

WEED MANAGEMENT IN COTTON

Effective weed management is one of many critical components of successful cotton production. Because cotton does not compete well with weeds, especially early in the season, a given number of weeds will reduce cotton yield more than corn or soybean yield (Figure 1). Weeds also may interfere more with harvesting of cotton and can reduce lint quality because of trash or stain.

Figure 1. Irrigated Cotton Seed Yield vs Glyphosate-Resistant Palmer Amaranth Density.



Crop Rotation

Crop rotation aids in the management of nematodes and diseases. Additionally, it can be a significant component of a weed management program. Crop rotation allows the potential use of herbicides with different modes of action on the same field in different years. By rotating cotton with other crops and selecting an herbicide program for the rotational crop that effectively controls the weeds that are difficult to control in cotton, one can reduce or prevent the buildup of problem weeds. **Crop rotation and properly planned herbicide rotation are also critical components of an herbicide resistance management strategy**.

When selecting an herbicide program for crops preceding cotton, consider rotational restrictions for the various products. This information can be found on herbicide labels. Many of the commonly used herbicides in other crops do not carry over to cotton. However, labels for products listed below contain significant rotational restrictions for cotton.

Authority Assist	Finesse Grass & Broadleaf	
Authority First	Impose	Scepter
Authority MTZ	Lightning	Sonic
Authority XL	Matador	Spartan
Cadre	Optill	Spartan Advance
Crossing	Pursuit	Spartan Charge
Extreme	Pursuit Plus	Thunder
Finesse	Python	

Similarly, several cotton herbicides including Cotoran, diuron, Envoke, fomesafen (Reflex, Dawn), Staple and Suprend have significant rotational restrictions to other crops.

Cultivation

Cultivation has traditionally been a significant component of cotton weed management programs. In addition to controlling weeds, cultivation may improve early season cotton growth in tight or crusted soils. On most soils, however, cultivation is of no value beyond weed control.

Eliminating cultivation reduces equipment and labor demands and the subsequent weed flushes, moisture loss, and root damage associated with the practice. Unfortunately, glyphosate-resistant Palmer amaranth has forced many growers to return to cultivation as a component of their weed management programs. Cultivation can be used to effectively manage small Palmer amaranth between cotton rows, rainfall or irrigation should be avoided for at least 48 hours after cultivation, if possible, to limit Palmer amaranth plants surviving the cultivation process.

Planning a Herbicide Program

Before selecting one or more herbicides, you should know what weeds are present or are expected to appear, the soil characteristics (such as soil organic matter and texture), the capabilities and limitations of the various herbicides, the weeds controlled by these herbicides, and how to best apply them.

Application rates for soil-applied herbicides depend on soil texture, organic matter content, and irrigation program. Failure to adjust application rates for soil characteristics and irrigation scheduling may result in poor weed control or crop injury.

Weed Mapping

The first step in a weed management program is to identify the problem. This is best accomplished by weed mapping. Survey the fields each fall and record on a field map the species and population levels present. Species present in the fall will likely be the predominant problems during the following year. You can better plan an herbicide program if you know ahead of time what species to expect. Additionally, by referring to weed maps over a period of two or three years, you can detect shifts in the weed populations and make adjustments in the herbicide program to deal with changes that occur.

In-Season Monitoring

During the first 8 weeks after planting, check fields every 3- to 5-days to determine the need for postemergence herbicides or cultivation. After eight weeks, check fields periodically to evaluate the success of the weed management program and to determine the need for preharvest control measures. If weeds are controlled for the first ten weeks, any later emerging weeds will seldom become problems. Proper weed identification is necessary because different weed species respond differently to various herbicides. Contact your local Extension office for aid in weed identification.

Weed Management in Conventional Cotton Varieties

Very little non-herbicide resistant cotton is now being grown in Georgia. Growers planting conventional cotton varieties can find detailed information on weed management in the *2012 Georgia Pest Control Handbook* or in Appendix V of this Production Guide.

Weed Management in LibertyLink and WideStrike Cotton

LibertyLink vs Widestrike: Crop Tolerance and Management Considerations

LibertyLink cotton was transformed to include the bacterial *bar* gene which codes for an enzyme that very effectively deactivates glufosinate (Ignite herbicide). LibertyLink cotton tolerance of Ignite is exceptional; crop injury from Ignite applied to LibertyLink cotton is simply not a concern. In Phytogen's Widestrike cotton, the *pat* gene from a soil bacterium was inserted for use as a selectable marker during transformation events for lepidopteran pest management. The *pat* gene also codes for the enzyme that deactivates glufosinate. Tolerance of varieties with the Widestrike trait to Ignite is not complete. In contrast to LibertyLink cotton which is highly tolerant of Ignite, some injury is expected when Ignite is applied to WideStrike cotton. The injury is most often leaf burn and chlorosis with occasional stunting and leaf drop, and can range from minor to rather significant.

According to a recent EPA interpretation, Ignite 280 herbicide can be applied to WideStrike cotton. **However, the grower is liable for any crop injury resulting from the application. Neither Bayer CropScience nor Dow AgroSciences/PhytoGen nor the University of Georgia recommend or warrant the use of Ignite on WideStrike cotton.**

The Ignite label currently allows three applications of 29 fluid ounces, for a season total of 87 ounces. Alternatively, one can apply 30 to 43 fluid ounces once followed by an application of 29 fluid ounces, for a season total of a maximum of 72 fluid ounces.

Because of weed resistance to glyphosate, and because herbicides with new modes are action are not being developed. Ignite will play a significant role in cotton weed management for the foreseeable future. It is imperative that growers follow sound resistant management strategies to avoid or delay selection for resistance to Ignite. In addition to diversifying and integrating other herbicides into a management program, growers are strongly encouraged to limit Ignite use to no more than two applications per year.

Research throughout the Southeast has not shown significant yield reduction of WideStrike cotton from two Ignite applications at 29 fluid ounces applied twice at 1- to 2-leaf cotton and again to 5- to 7-leaf cotton. Rates in excess of 29 fluid ounces are discouraged; higher rates cause more burn with possible stunting and leaf drop. The addition of ammonium sulfate and other herbicides is discouraged. Additionally, application after the eight-leaf stage of WideStrike cotton should be avoided. Application near first bloom or later may cause unacceptable crop injury, leaf drop, and possible yield reduction.

An advantage of LibertyLink cotton compared to Widestrike cotton is that one can apply a higher rate of Ignite as well as apply labeled Ignite tank mixtures without concern for crop response. On the other hand, most Phytogen varieties with the WideStrike trait also contain the Roundup Ready Flex trait. Hence, Ignite and glyphosate can be applied to these varieties whereas glyphosate cannot be applied to LibertyLink varieties. Tank mixes of Ignite and glyphosate will be discouraged for 2012 because additional research is needed regarding potential antagonism. Glyphosate does not impact the activity of Ignite, but research from other areas suggests Ignite can antagonize glyphosate. Thus, one should separate applications by three days if glyphosate is applied first, or at least seven days if Ignite is applied first.

GlyTol LibertyLink cotton will be commercialized with limited quantities available for a few growers during 2012. This technology will offer growers the ability to topically apply Ignite or Roundup, similar to Widestrike cotton, but without concern for crop injury.

In deciding upon a LibertyLink versus a Widestrike variety versus a GlyTol LibertyLink variety, growers are encouraged to study all available variety trial data.

Timing of Application

The optimum weed size for treatment with Ignite 280 varies, depending on the weed species and growing conditions. Pigweeds, tropic croton, spurred anoda, velvetleaf, Florida beggarweed, eclipta, groundcherry, spotted spurge, common purslane, and annual grasses should be no more than 3 inches tall (tallest plant in the field should be 3 inches or less). Goosegrass should be 2 inches or less. Under dry or other stressful conditions, Palmer amaranth and all annual grasses should be 2 inches or smaller when treated.

Application Equipment

Ignite 280 behaves much like a contact herbicide. Hence, good spray coverage is necessary. Growers must study and understand the relationship of speed, pressure, and nozzle type to make sure they are delivering a medium size droplet if they are to maximize Ignite efficacy. Understanding this relationship is critical for successful control of glyphosate-resistant Palmer amaranth.

Need for Soil-Applied Herbicides

Preplant and/or preemergence residual herbicides are strongly encouraged in LibertyLink, Widestrike, and GlyTol LibertyLink cotton. These herbicides help control annual grasses, pigweeds, Florida pusley, and Tropical spiderwort, the common weeds that are difficult to control with Ignite. These herbicides will also allow greater flexibility in timing of the first Ignite application. And, most importantly, they will help prevent selection for Ignite-resistant weeds.

Tank Mixes With Ignite 280 Applied Overtop

Staple LX can be mixed with Ignite 280 applied overtop. The typical rate of Staple LX would be 1.3 to 1.9 fluid ounces per acre to improve control of emerged sensitive species and to provide residual control or suppression of sensitive species such as pigweeds. The Staple LX rate can be increased to 2.6 fluid ounces per acre to improve control of troublesome weeds. Staple will not control biotypes of palmer amaranth resistant to ALS herbicides.

Dual Magnum can be tank mixed with Ignite 280 applied overtop to emerged cotton until 100 days prior to harvest. Dual Magnum will not improve control of emerged weeds. If activation is timely, it will provide residual control of annual grasses and pigweed species. The Ignite label currently specifies Dual Magnum as the choice of metolachlor to use.

Do not tank mix both Dual Magnum (or generic metolachlor) and Staple LX with Ignite!

Post Graminicides should not be mixed with Ignite because of reduced grass control.

Directed Herbicides in LibertyLink or WideStrike Cotton

Conventional herbicide chemistry is strongly encouraged at time of layby, especially diuron plus MSMA when managing Palmer amaranth. Additionally, Ignite should not be applied more than twice during the season.

However if one decides to use Ignite it can be directed to LibertyLink or WideStrike cotton up to the early bloom stage and a labeled tank mix partner should always be included.

Difficult-to-Control Weeds in Ignite-Based Systems

Florida pusley. Ignite has little activity on Florida pusley and successful management will depend on the use of an effective soil-applied herbicide.

Pigweed species. Pigweed species, including Palmer amaranth, can be controlled by Ignite 280 as long as the application is made when the largest pigweed in the field is 3 inches tall. An at plant herbicide system with residual control is required.

Goosegrass and other annual grasses. In general, Ignite 280 is more effective on broadleaf weeds than grasses. Timing of application to grasses, and especially goosegrass, is critical. Two applications of Ignite are normally needed to control goosegrass. A soil-applied herbicide, such as Prowl or Treflan incorporated or Prowl or Cotoran preemergence, can help tremendously in controlling goosegrass and other annual grasses. Dual Magnum mixed with Ignite will not improve control of emerged grasses, but it can provide residual control. This can be important in control of goosegrass as this grass often emerges later in the season.

Ignite 280 should not be tank mixed with postemergence grass-control herbicides. These tank mixes are very antagonistic (reduced grass control). If additional grass control is needed, any of the grass-control herbicides (Assure II, Fusilade DX, Poast, Select, Select max) can be applied 3 days before or 7 days after Ignite 280.

Nutsedge. Ignite burns nutsedge but the weed usually grows back. Adequate nutsedge control can often be obtained by planting into a clean seed bed followed by an Ignite 280 application during early season followed by Envoke as soon as cotton is reaches the appropriate state of growth followed by one or two directed MSMA application.

Dayflower and Doveweed. Ignite will not control spreading dayflower. This weed can be controlled with Staple LX applied postemergence at 2.6 fluid ounces per acre or directed herbicide combinations containing MSMA. Postemergence herbicides should be applied when spreading dayflower shoots are less than 3 inches. Ignite has some activity on dove weed; however, the weed usually grows back. Gramoxone, applied under a hood, is very effective on dove weed. Additionally, preliminary results indicate that Dual Magnum if applied before dove weed germination and Valor plus MSMA directed to emerged doveweed can be effective.

Tropical Spiderwort. Ignite is not very effective on tropical spiderwort. Therefore, Cotoran should be applied at planting followed by an early POST application of Ignite plus Dual Magnum applied before spiderwort emerges, and Direx or Valor plus MSMA at layby would be in order. Additionally, cultivation or hooded applications of Gramoxone also may be required.

Weed Management in Roundup Ready Flex Cotton

Comparing Glyphosate Brands

A number of brand names and formulations of glyphosate are available. Most currently available products are formulated as isopropylamine salts or potassium salts, although a few products are formulated as dimethylamine salts or as mixtures of isopropylamine salt and ammonium salt or

mixtures of ammonium salt and potassium salt. Products vary in their concentration of active ingredient. Labels for some brands direct the user to add nonionic surfactant. Other brands are "loaded formulations," meaning additional surfactant is not necessary. Read the label of the brand used to determine need for surfactant.

The higher application rates allowed on Roundup Ready Flex cotton may occasionally lead to contact burn on cotton foliage. This burn is usually minor, but severe burn has occasionally been noted. The severe burn seems to be associated with generic brands containing active ingredient made in China.

Timing of Application: Roundup Ready Flex Varieties

Not all brands of glyphosate are labeled for overtop application to Roundup Ready Flex cotton after the four-leaf stage; check label before applying. Brands of glyphosate with specific labeling for Roundup Ready Flex cotton may be applied overtop or directed to Roundup Ready Flex varieties any time from cotton emergence until seven days prior to harvest. The maximum rate for any single application between crop emergence and the 60% open boll stage is 1.125 pounds a.e. A total of 4.5 pounds a.e can be applied during this time frame. An additional 1.55 pounds a.e. per acre can be applied from the 60 percent open boll stage until seven days prior to harvest.

Need for Soil-Applied Herbicides

With the rapid spread of glyphosate-resistant Palmer amaranth, residual at-plant herbicides are required to grow any cotton crop in Georgia.

Should replanting be necessary where soil-applied herbicides have been used, it is best to run the planter back in the original drill without any soil preparation if soil conditions permit. In this case, do not apply any additional residual herbicides. If weeds have emerged, glyphosate or paraquat can be applied for burndown. Paraquat or Aim will control small emerged cotton. Ignite is also effective controlling cotton as long as it is not a cotton cultivar tolerant to Ignite such as Liberty Link or Widestrike.

If reworking the seedbed is necessary, use shallow tillage such as light disking. Do not apply additional preplant-incorporated herbicides. If the original preemergence herbicide was broadcast, do not apply any more unless enough time has passed where herbicides have degraded to the point that they are no longer biologically active. If the preemergence herbicide was originally banded, a second preemergence banded application would be in order.

Do not re-bed without first disking. Re-bedding without disking can lead to severe injury.

Over-the-Top Tank Mixes with Glyphosate

Assure II, Fusilade DX, Poast, Poast Plus, or Select Max can be mixed with glyphosate applied to Roundup Ready Flex cotton to control volunteer Roundup Ready corn.

Dual Magnum can be applied overtop of Roundup Ready cotton from emergence until 100 days prior to harvest. Crop injury from glyphosate plus Dual overtop is typically minor, with necrotic speckling noted on leaves contacted. This injury is temporary; no speckling on later-emerging leaves, no stunting, and no adverse effect on yield or maturity have been noted. The exception has been when additional adjuvants or some insecticides are included in the mixture or when

applications are made when heavy dew is on the cotton or when the weather is extremely hot and humid.

Mixing Dual Magnum with glyphosate will have no effect on emerged weeds by glyphosate. However, if timely rainfall/irrigation for activation is received, Dual Magnum can provide residual control of most annual grasses (suppression of Texas millet), pigweed species (including Palmer amaranth), doveweed, and tropical spiderwort (control for 21 to 35 days), and suppression of yellow nutsedge and spreading dayflower. Dual Magnum mixed with glyphosate will likely broaden the window of application for directed herbicides on Palmer amaranth.

Generic brands of metolachlor are available. Growers should be aware that some generics (Brawl and Medal are exceptions) are not the same as Dual Magnum. Metolachlor is a mixture of four stereo-isomers. Two of the isomers (referred to as *S*-metolachlor) are herbicidally active whereas the other two isomers (referred to as *R*-metolachlor) have little herbicidal activity. Labels for most generic brands refer to the active ingredient as "metolachlor", meaning it is the mixture of active and inactive isomers. The active ingredient in Dual Magnum is "*S*-metolachlor", the active isomers. Georgia research has shown that "metolachlor" products applied at the same rate as "S-metolachlor" products will likely not provide the same length of residual control. The "metolachlor" product use rate would need to be increased by 50 percent to get the same activity as "S-metolachlor".

Do not tank-mix Dual Magnum (or any generic) and Staple LX.

Envoke at 0.1 oz of product per acre can be mixed with Roundup brands of glyphosate, Touchdown HiTech, Touchdown Total, or Traxion and applied overtop of Roundup Ready Flex cotton from the 5-leaf (prefer 7-leaf) to the 12-leaf stage. Injury and plant stunting will likely occur; thus, this mixture should be tried on limited acreage. Envoke mixed with glyphosate will improve control of nutsedge, hemp sesbania, and larger *Ipomoea* morningglory (will not enhance smallflower morningglory control) compared to glyphosate alone.

Sequence is a prepackaged mixture of the potassium salt of glyphosate and *S*-metolachlor. Applied at 2.5 pints per acre, Sequence is equivalent to 0.7 lb acid equivalent of glyphosate plus 1 pint of Dual Magnum.

Staple LX can be mixed with glyphosate and applied overtop of Roundup Ready Flex cotton from the cotyledonary stage until 60 days prior to harvest. Staple LX is typically applied at 1.3 to 1.9 fluid ounces when tank mixed with glyphosate. Salvage applications do allow increased rates of Staple up to 3.8 fluid ounces (see label).

A mixture of glyphosate plus Staple will improve control of hemp sesbania, morningglory (except tall morningglory), spreading dayflower, tropical spiderwort, and glyphosate-resistant Palmer amaranth (assuming it is not also ALS-resistant) as compared with glyphosate alone. Staple will give some residual control of susceptible weeds such as pigweed species. Palmer amaranth resistant to Staple and other ALS inhibitors is present in MANY Georgia fields.

Compared to glyphosate alone, a mixture of glyphosate plus Staple may injure cotton. Applied overtop, Staple often causes temporary yellowing of the cotton bud. Research has demonstrated that cotton recovers quickly, and there is seldom an adverse effect on yield or maturity. On occasion, however, Staple applied overtop can cause moderate to severe injury. The potential for

significant injury from Staple appears to be greater when the herbicide is applied during or shortly before a period of cool temperatures and when dew is present on the cotton at time of application. Other stresses such as wet weather, seedling disease, or thrips damage may worsen injury.

Warrant can be used in a manner similar to Dual Magnum. Warrant plus glyphosate can be applied topically after cotton is completely emerged but before first bloom. Weed control and crop tolerance is similar to that with Dual Magnum. Warrant does not control emerged weeds. Best results will be obtained, especially on Palmer amaranth, if Warrant plus glyphosate is applied just prior to 1 leaf cotton before Palmer amaranth emerges. A second application as a directed spray may be made.

Do not tankmix Warrant with Staple.

Glyphosate versus Other Directed Herbicides

In Roundup Ready Flex cotton, you have the option of directing either glyphosate or a traditional herbicide combination. **With the current issue regarding glyphosate-resistant Palmer amaranth, conventional herbicide chemistry should be used on nearly every Georgia cotton field.** However, if grasses are a predominant problem and they are larger than one inch, glyphosate will be the more effective option to control these grasses. If one decides to use glyphosate, mixing other labeled herbicides with glyphosate is encouraged thereby possibly improving postemergence weed control, providing residual weed control, and assisting in resistance management.

Directed Tank Mixes with Glyphosate

Potential tank-mix partners with glyphosate applied postemergence-directed include Aim, Caparol, diuron (Direx, others), Dual Magnum, Envoke, ET, Staple, Suprend, Valor and Warrant.

Aim and ET are very effective on morningglory, and when mixed with glyphosate will improve control of larger morningglory and Florida pusley compared to glyphosate alone. Additionally, Aim will provide excellent control of emerged tropical spiderwort that is four inches or less. Cotton should be at least 18 inches tall, and the spray must be directed precisely to the woody portion of the stem. Spray contact with green stem tissue will cause injury. Neither product provides residual control.

Caparol or diuron mixed with glyphosate will improve morningglory control compared to glyphosate alone. Caparol at 2 pints or Direx (diuron 4L) at 1.5 pints will provide some residual control of small-seeded broadleaf weeds, such as pigweed, if activated by rainfall. Direx (diuron) is usually more effective on Palmer amaranth than Caparol. Cotton should be at least 12 inches tall before directing Caparol or Direx at these rates. Occasionally, mixing Caparol or Direx with glyphosate will reduce grass control by glyphosate. This is most likely to occur under dry growing conditions when grasses are large. Do not reduce the glyphosate rate when tank-mixing.

Dual Magnum mixed with glyphosate will have no effect on control of emerged weeds by glyphosate. However, if Dual Magnum is activated by rainfall, it will provide residual control of annual grasses (Texas millet is only suppressed), pigweed species, doveweed, and tropical spiderwort, and suppression of yellow nutsedge. This combination can be directed to cotton from 3 inches tall until 80 days prior to harvest.

Envoke mixed with glyphosate will improve control of nutsedge, hemp sesbania, and larger *Ipomoea* morningglory (will not enhance smallflower morningglory control) compared to glyphosate alone. Cotton should be at least 6 inches tall. Preliminary research indicates Envoke has more residual activity on broadleaf weeds than originally thought. Palmer amaranth resistant to Envoke and other ALS inhibitors is present in many Georgia fields.

Staple LX mixed with glyphosate will improve control of hemp sesbania, morningglory (except tall morningglory), spreading dayflower, tropical spiderwort, and glyphosate-resistant Palmer amaranth as compared with glyphosate alone. Staple also may give some residual control of susceptible weeds such as pigweed species. Palmer amaranth resistant to Staple and other ALS inhibitors is present in many Georgia fields.

Suprend is a mixture of the active ingredients in Caparol and Envoke. Suprend mixed with glyphosate will improve control of larger morningglory and nutsedge. It also will provide residual control of susceptible broadleaf weeds. Cotton should be at least 8 inches tall when directing Suprend.

Valor SX mixed with glyphosate will improve control of dove weed, larger morningglory, Florida pusley, and tropical spiderwort compared to glyphosate alone. Cotton should be at least 16 inches tall and the stem should be completely "woody" before this combination is precisely directed to the bottom 1 to 2 inches of the cotton stem. Add nonionic surfactant at 1 qt per 100 gal spray solution if glyphosate brand requires adjuvant. DO NOT use crop oil concentrate, methylated seed oil, organo-silicone adjuvants, or any adjuvant product containing these. Valor, if activated by rainfall, will provide excellent residual control of pigweed species including Palmer amaranth, Florida pusley, and many other broadleaf weed species. Valor has a very favorable rotational package, see label.

Warrant can be mixed with glyphosate and directed to cotton up to first bloom. Warrant will not control emerged weeds, but if activated with timely rain, it will provide residual control of annual grasses and small-seeded broadleaf weeds, including Palmer amaranth.

Weeds Hard to Control with Glyphosate

Bermudagrass: The most effective method to manage severe bermudagrass populations is a fall application of glyphosate at the maximum use rate followed by glyphosate or postemergent graminicides in the following crop. Postemergence graminicides (Select, Select Max, Fusilade DX, Assure II) may be more effective than glyphosate in controlling immature bermudagrass with runners less than 6 inch.

Doveweed: Glyphosate will not control doveweed. Dual Magnum will control doveweed well if the herbicide is applied and activated before doveweed germination. Paraquat applied with a hooded sprayer will also control doveweed. And, directed applications of Valor plus MSMA, Valor plus glyphosate, and diuron plus glyphosate appear to be fairly effective.

Florida pusley: Florida pusley can be controlled by glyphosate but ONLY if applied at the full rate when the weed is very small (1 inch or less) and under favorable growing conditions; multiple applications are sometimes necessary. One SHOULD use a preplant incorporated or preemergence herbicide. Both yellow herbicides as well as Cotoran or diuron control this weed if applied properly and activated by rainfall.

Hemp Sesbania: Hemp sesbania is very difficult to control with glyphosate after the first true leaf. When hemp sesbania is expected to be a problem, soil applied herbicides such as Cotoran are in order. Follow with a glyphosate plus Staple postemergence application and then a postemergence-directed application of a traditional herbicide combination. Combinations containing Cobra, Envoke, or Suprend would be a good option for the directed application. Envoke applied overtop of cotton would also be an option but the sesbania may be greater than 3 inches when the label allows Envoke to be applied topically to cotton.

Morningglory: One application of glyphosate usually will not adequately control morningglory. It will, however, halt growth of small morningglory so that the weed can be taken out with cultivation, a second application of glyphosate, or a later application of a conventional directed herbicide. Cotoran or Staple applied preemergence also will aid in control of morningglory. For morningglory (except the species tall morningglory) 3 inches or larger, a tank mix of glyphosate plus Staple is more effective than glyphosate alone. Envoke also is very effective on *Ipomoea* morningglory but should only be mixed with glyphosate and applied to Roundup Ready FLEX cotton between the 7- and 12-leaf stage.

At time of layby or directed applications, conventional chemistries such as MSMA plus Caparol, Cobra, diuron, Layby Pro, Suprend, or Valor would be more effective than glyphosate. However if one chooses to use glyphosate, the addition of Aim, Caparol, diuron, Envoke, ET, Staple, Suprend, or Valor would be beneficial (see labels for application timings and cotton sizes).

Nutsedge: Two applications of glyphosate at the maximum use rate normally controls yellow and purple nutsedge. Good results also have been obtained with the full rate of glyphosate applied overtop followed by a directed application containing MSMA at 2.5 pints per acre or Envoke at 0.15 ounce per acre. In severely infested fields, best results will be obtained with two overtop applications of glyphosate at the full rate followed by a directed application mixture including MSMA, Envoke, or Suprend. Do not mix MSMA with glyphosate and apply overtop of cotton.

Volunteer Roundup Ready corn. Assure II, Fusilade DX, Select or Select Max may be applied alone or mixed with glyphosate and applied overtop to control Roundup Ready corn in Roundup Ready cotton. Suggested rates include the following: 5 or 8 ounces of Assure II on corn up to 18 or 30 inches, respectively; 6 ounces of Fusilade DX on corn up to 24 inches; or 4 to 6 ounces of Select on corn up to 12 or 24 inches, respectively; or 8, 10, or 12 oz of Select Max on corn up to 8, 18, or 24 inches, respectively. See labels for these products concerning maximum corn size and use of adjuvants when applying alone or mixed with glyphosate.

Volunteer Roundup Ready soybeans. Cotoran applied preemergence may provide adequate control. Staple alone typically does not adequately control volunteer soybean. However, Staple applied to three- to four-trifoliate soybean followed by a directed application of Caparol, diuron, or Suprend plus MSMA may provide adequate control. The most effective option to control volunteer soybean is Envoke applied overtop to soybeans with less than six trifoliate leaves (see www.cotton.org/journal/2005-09/2/upload/jcs09-102.pdf). Envoke may not control soybean that is taller than about 12 inches.

Managing Tropical Spiderwort in Roundup Ready Cotton

Tropical spiderwort is a noxious, exotic, invasive weed that has spread quickly and has become a serious pest in many Georgia production areas. Increased prevalence of tropical spiderwort in Georgia may be attributed in part to 1) adoption of weed management programs that lack residual

herbicides and 2) adoption of reduced-tillage production systems. Additionally, the rapid spread of this pest has been influenced by the spread of birds including doves.

The following 3 tables are suggestions for the management of different levels of tropical spiderwort infestations in Georgia Roundup Ready cotton. ***Refer to Appendix V or the pest control handbook for herbicide rates and proper cotton sizes at time of application.***

Table 1. Managing **SEVERE** Infestations of Tropical Spiderwort in Roundup Ready (RR) Cotton.*****

Preemergence	Postemergence (1- to 4-leaf cotton)	Layby Directed[2]
(Planting before May 10) Use at-plant herbicides appropriate for other weeds	Sequence (2.5 pt/A) [1] or glyphosate + Warrant (3 pt/A) (Spiderwort should be less than 1 inch and the herbicide must ***completely*** cover the soil)	diuron + MSMA + Dual Magnum[1] (8-12 oz/A)
(Planting after May 10) Cotoran + other herbicides appropriate for other weeds		

*****Deep turning the land will provide fair control of spiderwort. This practice may be needed in addition to herbicides in some fields.
1. Dual Magnum and Sequence contain S-metolachlor. Other generic brands contain metolachlor, a mixture of R and S isomers. Per unit of product, brands containing S-metolachlor provide longer control.
2. Diuron+MSMA+Dual is often a little more effective than glyphosate+Aim+Dual because of additional residual control provided by diuron. In areas where hooded applications are available, glyphosate + Valor + Dual would be similarly effective.

Table 2. Managing **MODERATE** Infestations of Tropical Spiderwort in RR Cotton.

Preemergence	Postemergence (1- to 4-leaf cotton)	Layby Directed
(Planting before May 10) Use at-plant herbicides appropriate for other weeds	Sequence (2.5 pt/A) [1] or glyphosate + Warrant (3 pt/A) (Spiderwort should be less than 1 inch and the herbicide must ***completely*** cover the soil)	diuron + MSMA or glyphosate + diuron or glyphosate + Aim + Dual Magnum[1] (8-12 oz/A)
(Planting after May 10) Cotoran + other herbicides appropriate for other weeds		

1. Dual Magnum and Sequence contain S-metolachlor. Other generic brands contain metolachlor, a mixture of R and S isomers. Per unit of product, brands containing S-metolachlor provide longer control.

Table 3. Managing **LIGHT** Infestations or **DELAYING** arrival of Spiderwort in RR Cotton.

Preemergence	Postemergence (1- to 4-leaf cotton)	Layby Directed
Use at-plant herbicide appropriate for other weeds	glyphosate + Dual Magnum[1] (16 oz/A) or Warrant (3 pt/A) (Spiderwort should be less than 1 inch and the herbicide must be able to *completely* cover the soil)	Valor + MSMA diuron + MSMA glyphosate + Valor glyphosate + diuron

1. Dual Magnum contains S-metolachlor. Other generic brands contain metolachlor, a mixture of R and S isomers. Per unit of product, brands containing S-metolachlor provide longer control.

Postemergence-Overtop Herbicides - Any Variety

Envoke can be applied overtop of cotton with a minimum of five (prefer 7) leaves up to 60 days prior to harvest. Directed application is encouraged on cotton larger than 10 inches to ensure better spray coverage on weeds below the crop canopy. Envoke controls or suppresses nutsedge plus a number of broadleaf weeds that are less than 4 inches in height. Note that Envoke does not control smallflower morningglory, jimsonweed, prickly sida, spreading dayflower, or tropical spiderwort, and it is not very effective on tropic croton or Palmer amaranth.

Envoke and Staple have the same mode of action. Hence, Palmer amaranth resistant to Staple will not be controlled by Envoke. Palmer amaranth resistant to both Staple and Envoke are now common across Georgia.

Cotton will sometimes be injured by Envoke applied overtop. Injury is expressed as yellowing in the growing point and shortened internodes. Some degree of crop response can almost always be expected. In most cases, injury is relatively minor and the crop recovers without an adverse effect on yield or quality. On occasion, however, moderate to severe injury has been observed. Smaller cotton appears to be injured more than larger cotton. Other factors contributing to crop injury are unknown. Growers are encouraged to not apply Envoke to cotton with less than seven leaves and to not apply the herbicide to cotton under stress from wet or dry weather or thrips. Also, carefully follow label directions for adjuvant usage, and do not tank mix Envoke with other herbicides (other than Staple, see label) when applying overtop cotton. Tank mix Envoke with only those insecticides specifically mentioned on the Envoke label. Tank mixes of Envoke and mepiquat chloride are strongly discouraged.

Tank mixes of Envoke with Assure II, Fusilade DX, Poast, Poast Plus, Select or Select Max should be avoided. Separate applications of Envoke and the grass-control herbicides by at least 3 days if the grass-control herbicide is applied first or 5 days if Envoke is applied first.

Staple LX can be applied overtop of cotton from the cotyledonary stage until 60 days before harvest. Two applications per year are allowed as long as the total applied per season does not exceed 5.1 fluid ounces.

If applied in a timely manner, Staple controls many broadleaf weeds. Note that Staple applied postemergence does not adequately control lambsquarters, ragweed, sicklepod, spurge, tall morningglory, or tropic croton. Timing of application is critical. Most susceptible broadleaf weeds should not be taller than 3 inches. Prickly sida must be 1 inch or less for acceptable control. Palmer amaranth should be 2 inches or less. Palmer amaranth resistant to Staple is now common across Georgia.

Tank mixes of Staple LX with Assure II, Fusilade DX, Poast, Poast Plus, Select or Select Max are not recommended because antagonism (reduced grass control) is often observed. When making sequential applications of Staple and a postemergence grass-control herbicide, apply the Staple at least 5 days before or 3 days after application of the grass-control herbicide.

Grass-control herbicides. Assure II, Fusilade DX, Poast, Poast Plus, Select, and Select Max can be applied overtop of cotton from emergence through mid-season. These products control annual and perennial grasses but are ineffective on nutsedge and broadleaf weeds. All of these products are safe on cotton and are effective when applied to small grasses under good growing conditions.

However, Poast, Poast Plus, Select, and Select Max tend to be more effective over a range of annual grass species and environmental conditions. When using any of these herbicides, follow label directions for application rates, application methods, use of adjuvants, and optimum grass size for treatment. Tank-mixing broadleaf herbicides, such as Staple or Envoke, with these postemergence grass-control herbicides is not recommended.

Postemergence-Directed Herbicides - Any Variety

A number of herbicide combinations are available for directed application to any variety of cotton and include the following: Caparol plus MSMA, Cobra plus MSMA, Cobra plus Direx plus MSMA, Cotoran plus MSMA, Direx plus MSMA, Layby Pro plus MSMA, Linex plus MSMA, Suprend plus MSMA, and Valor SX plus MSMA. Dual Magnum, Aim, and ET may be mixed with some of these herbicide combinations. Although Staple and Envoke could be used at layby, we encourage using alternatives to reduce the potential for further resistance development.

The postemergence-directed herbicides listed above are primarily for annual broadleaf weeds and nutsedge. MSMA in these mixtures will control annual grasses less than 1.5 inches. Except for Aim, ET, MSMA, and Cobra plus MSMA, the options listed above will also provide some residual control of sensitive weeds.

See comments in Appendix V and herbicide labels for minimum cotton size to treat, maximum weed size, application directions and precautions, and rotational restrictions.

Perennial Broadleaf Weeds

Perennial broadleaf weeds, such as horsenettle, trumpetcreeper, common milkweed, and hemp dogbane, are primarily a problem in no-till situations. Soil-applied herbicides will not control perennial broadleaf weeds, and, with the exception of horsenettle, conventional postemergence-directed herbicides are ineffective. Acceptable control of horsenettle has been obtained with postemergence-directed herbicide combinations containing MSMA. Two applications of MSMA or combinations containing MSMA usually be needed. Other species can be suppressed or controlled in non-Roundup Ready cotton by glyphosate applied with a hooded sprayer. Harvest-time applications of glyphosate are also an option to suppress perennial weeds for the following year (see “Preharvest Herbicide Application”).

Perennial broadleaf weeds can be suppressed or controlled with multiple applications of glyphosate applied to Roundup Ready cotton. Later applications are generally more effective on perennials, and two applications are more effective than one. Adequate spray coverage should be obtained on low-growing perennials such as trumpetcreeper and horsenettle with standard directed sprayers.

Curly dock is best controlled by a preplant application of Harmony Extra.

Perennial broadleaf weeds can be suppressed or controlled in corn grown in rotation with cotton. In corn, an early postemergence application of dicamba alone or mixed with a nicosulfuron-containing herbicide followed by a lay-by application of dicamba is most effective. Alternatively, glyphosate or a tank mix of 2,4-D plus dicamba can be applied to infested spots after corn harvest.

Preharvest Herbicide Application

Preharvest herbicide applications are of questionable value in most cases. Desiccating mature weeds likely will not increase harvesting efficiency nor reduce harvesting losses. The major

exception would be fields heavily infested with viney weeds such as morningglory and cowpea. Problems with extraneous green matter in harvested cotton are probably overstated. Lint staining from weeds has not been voiced as a significant problem in spindle-picked cotton. Desiccating weeds will more likely increase rather than decrease trash in cotton because gins can remove green plant parts more easily than finely ground, desiccated plant parts. However, if present in large quantities, extraneous green matter can increase the potential for overheating, rot, and stain if the cotton is packed into a module and the module is not properly monitored.

There are no established guidelines for determining when the level of weed infestation justifies a preharvest herbicide application. The information below is based on general observations.

Annual Weeds

Aim or ET. These herbicides are also registered for use as defoliants. Good desiccation of morningglory and cocklebur have been observed with excellent spray coverage. Results on pigweed species have been inconsistent but generally not acceptable. These products will not desiccate grasses or sicklepod. See labels regarding use of adjuvants.

Glyphosate. In non-Roundup Ready cotton, tank-mix 0.75 to 1.5 pounds acid equivalent of glyphosate with the defoliate when at least 60 percent of the bolls are open. The glyphosate should be applied at least 10 days before anticipated harvest. Glyphosate-defoliant combinations generally have been effective on annual grasses, common ragweed, lambsquarters, pigweed, cocklebur, tropic croton, cowpea, and sicklepod. In most cases, cotton leaf re-growth suppression has been observed on non-Roundup Ready cotton.

Glyphosate can be applied in Roundup Ready Flex varieties seven or more days ahead of harvest regardless of the percentage of open bolls. Remember that glyphosate will not suppress regrowth on Roundup Ready cotton.

Gramoxone. Either add 2 to 6 oz of product with standard defoliants or apply after cotton defoliation. When applying after cotton defoliation and at least 80 percent of the bolls are open, the remaining bolls expected to be harvested are mature, and most of the cotton leaves have dropped, apply 1.9 pints of Gramoxone SL. Broadcast the Gramoxone in a minimum of 20 gallons of water per acre and add 1 pint of nonionic surfactant per 100 gallons of water. Initiate harvest as soon as leaves are toughened (the "green" is removed) but before foliage becomes brittle. Gramoxone will desiccate most annual weeds with Florida pusley being an exception.

Perennial Weeds

Glyphosate can be applied in the fall to control or suppress perennial weeds for the following year. For johnsongrass control, glyphosate at a rate of 0.75 to 1.5 pounds acid equivalent per acre may be tank-mixed with the defoliant. Apply when at least 60 percent of the bolls are open. Alternatively, glyphosate may be applied after defoliation. Application after defoliation may be preferred in rank cotton to improve spray coverage. Additionally, a separate application of glyphosate allows treatment of only the infested areas of a field, thus reducing herbicide cost.

For other perennial weeds, such as bermudagrass, nutsedge, trumpetcreeper, horsenettle, common milkweed, and hemp dogbane, glyphosate-defoliant tank mixes are not recommended. If you need to control these weeds, defoliate the cotton as usual. Apply the glyphosate after most of the cotton leaves have dropped. Maximum labeled use rates are suggested for nutsedge, trumpetcreeper, common milkweed, bermudagrass, horsenettle and hemp dogbane. Higher rates may be able to be used after harvest. To reduce costs, spot-spray only infested areas.

Glyphosate should be applied at least 7 to 10 days before the first killing frost.

Herbicide Resistance Management

Herbicide resistance in weeds is not a new problem. The threat posed by herbicide resistance has, however, recently been elevated to a much higher level. Horseweed, ryegrass, johnsongrass, and common ragweed resistant to glyphosate is scattered across the country and Palmer amaranth resistant to glyphosate, ALS-herbicides (Staple, Envoke, Cadre), DNA-herbicides (Treflan, Prowl), and/or atrazine have been confirmed in most major agronomic producing Georgia counties.

In previous years, growers with herbicide-resistant weeds were fortunate to have new herbicides (specifically, new mechanisms of action) come into the marketplace before the problem became overwhelming. That is not the case for the foreseeable future; new modes of action are simply not on the horizon. It is therefore imperative that growers take herbicide resistance management very seriously in an attempt to maintain usefulness of current products.

What Causes Resistance?

Herbicide resistance is the inherited ability of a biotype of a weed to survive and reproduce following exposure to a dose of herbicide normally lethal to the wild type. Herbicides do not cause resistance. Rather, herbicides select for resistance naturally occurring in the population. Greater reliance on a particular herbicide, or group of herbicides, with the same mode of action puts greater selection pressure on any resistant individuals that may be in the population. A shift to reduced tillage production has led to greater reliance on herbicides and greater problems with resistance.

Resistance Management Strategies

There are two prerequisites for resistance. First, one or more individuals possessing genes conferring resistance must be present in the population. Second, selection pressure resulting from extensive use of a herbicide to which these rare individuals are resistant must be exerted on the population. Growers have no way to know if a few plants carrying resistance are present on their farm. Hence, the only way to prevent a buildup of resistant plants is to utilize management systems that reduce selection pressure on any resistant individuals that may be present.

Greater than 95 percent of cotton in Georgia is planted to Roundup Ready varieties. A similar percentage of soybean and an increasing percentage of corn is also being planted to Roundup Ready varieties. In the past, growers relied almost exclusively on glyphosate for weed control. Extensive reliance on a single mode of action (the mechanism by which the herbicide kills susceptible plants) over that much acreage put tremendous selection pressure on resistant weeds present in the population and this is one of the reasons glyphosate-resistant Palmer amaranth currently dominates our agronomic landscape. Use of PPO herbicides such as Reflex and Valor SX has increased dramatically in cotton and other crops with the greater occurrence of glyphosate-resistant biotypes. There is concern that the use of these herbicides repeatedly will result in selection for PPO-resistant biotypes. Similarly, reliance on Ignite in LibertyLink or WideStrike cotton as the primary mode of action for weed control will select for resistance to Ignite. It is absolutely essential that herbicide programs be diverse in mode of action in order to reduce selection pressure for resistant weeds.

A key component of a resistance management strategy is to integrate herbicides with different modes of action into the cropping system. Appendix VII is included as an aid for growers to select herbicides with various mechanisms of action. The table list brand names and active ingredients of herbicides used in agronomic crops. In addition, there is a numeric code for each mode of action. An effective resistant management strategy will incorporate herbicides having four or more modes of action in cotton. Additionally, growers are encouraged to minimize their reliance on ALS-inhibiting herbicides as these chemistries are extremely vulnerable to resistance.

Cotton growers can incorporate the recommended diversity in modes of action into a glyphosate-based or glufosinate-based management program by using soil-applied residual herbicides, tank mixing another herbicide with glyphosate or glufosinate applied postemergence, and using alternatives to glyphosate at layby. Use of full rates of glyphosate or glufosinate, even in tank mixes, is strongly encouraged. Crop rotation can aid in resistance management if herbicide mode of action for the rotational crops are wisely selected. Where practical, tillage such as deep turning, disking, and/or cultivation would also be a very effective component of a resistance management strategy.

Glyphosate-Resistant Horseweed

Glyphosate-resistant horseweed (also called marestail) has been confirmed in most states surrounding Georgia and is expected to be present in North Georgia. Horseweed primarily emerges in the fall and will often be in a rosette stage and large enough for identification in January or February. Pictures of small horseweed and identifying characteristics can be found at www.ppws.vt.edu/scott/weed_id/erica.htm.

It is critical that glyphosate-resistant horseweed be controlled before planting cotton; options to control this weed after emergence of Roundup Ready or conventional cotton varieties are very limited. Glyphosate-resistant horseweed can be controlled by tank mixes of glyphosate plus 0.95 pound a.e. of 2,4-D (2 pints of typical 3.8 lb a.e./gal formulation) or glyphosate plus 0.5 pint of Clarity. The tank mix with 2,4-D at this rate should probably be at least 30 days ahead of planting. Cotton planting must be delayed at least 21 days after the accumulation of 1 inch of rainfall following Clarity application.

Horseweed that germinates in the fall can be controlled by winter burndown programs including 2,4-D or Clarity. However, plants that emerge late in the spring after burndown can become problematic. Valor has poor postemergence activity on horseweed; hence adding Valor to glyphosate will not improve control of emerged plants. However, Valor has good preemergence activity on horseweed. Valor included in a tank mix of glyphosate plus 2,4-D or glyphosate plus Clarity will reduce problems with late-emerging horseweed. Weed scientists in Tennessee have found that Cotoran applied preemergence is probably the best option to control late-emerging horseweed. Gramoxone should be included with the Cotoran to kill emerged weeds.

Although somewhat less effective than a tank mix of glyphosate plus 2,4-D or Clarity, a mixture of Gramoxone plus Direx may adequately control horseweed if the mixture is applied when daytime temperatures exceed 70 degrees F. Warm temperatures are critical for success with this treatment.

Ignite 280 at 29 ounces per acre will also control horseweed if applied when daytime temperatures exceed 75 degrees F. Ignite 280 is an option to control spring-emerging horseweed at planting time or in situations where growers have failed to follow one of the programs

previously outlined. Ignite 280 can be applied anytime prior to cotton planting. It is critical that Ignite 280 be applied under warm conditions. HOWEVER, if one is planning to use an Ignite-based system for the control of glyphosate-resistant Palmer amaranth, an alternative to Ignite for burndown is needed. This will reduce selection pressure on the Palmer amaranth population.

Ignite 280 is the only option to control glyphosate-resistant horseweed in emerged cotton with either topical applications in tolerant cultivars or in hooded applications in Roundup Ready or conventional cottons.

Glyphosate-Resistant Palmer Amaranth

Palmer amaranth is Georgia's most problematic weed in cotton. Two Palmer amaranth per 20 row feet can reduce cotton yield 23 percent, and a single female plant has produced 450,000 seeds when competing with cotton for an entire season in dryland cotton production. Palmer amaranth resistant to glyphosate was confirmed in 69 Georgia counties by the end of 2010.

Glyphosate-resistant Palmer amaranth is the most serious pest problem facing Georgia growers since the boll weevil. Growers must take this threat very seriously. That means undertaking an aggressive program to control existing resistant populations and a proactive program to reduce further selection for resistant biotypes to glyphosate and other herbicide chemistry.

Palmer amaranth is a dioecious plant, meaning there are separate male and female plants. Hence, it is an obligate outcrosser; pollen must move from male to female plants for seed production to occur. Research in Georgia has demonstrated that resistant pollen can move at least 1,000 feet and fertilize susceptible females. At least some of the offspring are resistant. Rapid spread can be expected through pollen movement and seed movement on equipment or gin trash. That implies that excellent control of existing glyphosate-resistant and -susceptible populations are necessary to slow its spread.

In formulating a resistance management program for Palmer amaranth and glyphosate, growers must keep foremost in their minds the need to prevent further selection for ALS resistance (Staple, Envoke, Cadre, etc.). Palmer amaranth resistant to both glyphosate and ALS-inhibiting herbicides has been confirmed in Georgia and becoming quite common. Such cross resistance is disastrous to cotton producer as Staple is the only herbicide available for overtop applications to Roundup Ready or conventional cotton to control emerged glyphosate-resistant Palmer amaranth. Hence, Staple and Envoke should be used in Roundup Ready cotton to control Palmer amaranth (and other weeds) only when other options are not suitable. Additionally, ALS inhibitors should be avoided when possible in crops grown in rotation with Roundup Ready cotton. There is also increasing concern over potential resistance to PPO inhibitors (includes the Authority products, Cobra, Flexstar, **Reflex, Valor,** Ultra Blazer, and others) and to **glufosinate** (Ignite 280). Although resistance to PPO inhibitors or glufosinate has not been encountered in the Southeast, growers are putting tremendous selection pressure on these herbicides and resistance is likely present, simply not confirmed yet.

Below, Tables 4 and 5 contain herbicide management programs for glyphosate-resistant Palmer amaranth in Roundup Ready and LibertyLink cotton. Also to help delay resistance, growers need to diversify crop production practices, including crop rotation and use of herbicides with different modes of action (Appendix VII).

For growers who are growing cotton in dryland production areas infested with glyphosate-resistant Palmer amaranth, use of an Ignite-based programs would be more effective than Roundup Ready programs if rainfall does not occur within 3 days of applying at plant residual herbicides.

Programs suggested for fields with known glyphosate-resistance are expensive, but a very aggressive program will be required to control glyphosate-resistant Palmer amaranth and to slow its spread. Note that Staple is recommended to control emerged glyphosate-resistant Palmer amaranth. This reliance on Staple emphasizes the need to prevent further ALS resistance. Also remember that Ignite will only control very small (less than 3 inch) Palmer amaranth.

Also, it is imperative that glyphosate-resistant Palmer amaranth be controlled in crops rotated with cotton, and this should be done with minimal reliance on ALS inhibitors. Because Staple is critical in a program to control glyphosate-resistant Palmer amaranth in cotton, it is a grower's best interest to prevent or at least slow further selection for ALS resistance.

Table 4. Managing glyphosate-resistant Palmer amaranth in Roundup Ready cotton.[1]

Preplant, Preplant Incorporated (PPI), or Preemergence (PRE)[2]	POST 1 (prior to 1-leaf cotton)	POST 2 (5-to 7-leaf cotton)	Layby
Irrigated -Conventional Tillage Reflex + Direx PRE or Reflex + Prowl PRE	glyphosate + Staple ***(Palmer 1" or less)*** or glyphosate + Dual Magnum or Warrant[3] ***(no Palmer emerged)***	glyphosate + Dual Magnum or Warrant[3] ***(no Palmer emerged)***	diuron + MSMA[4]
Reflex + Staple PRE or Direx + Staple + Prowl PRE	glyphosate + Dual Magnum or Warrant[3] ***(no Palmer emerged)***	glyphosate + Dual Magnum or Warrant[3] ***(no Palmer emerged)***	diuron + MSMA[4]
Conservation Tillage[5] Diuron and/or Valor preplant burndown followed by Diuron or Prowl + Reflex PRE	glyphosate + Staple ***(Palmer 1" or less)*** or glyphosate + Dual Magnum or Warrant[3] ***(no Palmer emerged)***	glyphosate + Dual Magnum or Warrant[3] ***(no Palmer emerged)***	diuron + MSMA[4]
Dryland – Conventional Tillage Treflan or Prowl + Reflex[6] PPI followed by diuron + Reflex[6] PRE	glyphosate + Staple ***(Palmer 1" or less)***	glyphosate + Dual Magnum or Warrant[3] ***(no Palmer emerged)***	diuron + MSMA[4]

[1] Follow all labeled herbicide use restrictions including application rates, plant back intervals, and use rates.
[2] The addition of paraquat is needed for all at-plant applications if Palmer is emerged at time of application; Roundup may be used instead if resistant Palmer is not emerged. Staple systems should be avoided if ALS-resistant Palmer amaranth is present.
[3] Make only one application of Dual Magnum per season. Consider directing Warrant if applied after the 5 leaf cotton stage of growth.
[4] Add an adjuvant. Will not control grasses larger than 1 in. If grasses greater than 1 inch are present, a glyphosate + diuron mixture is in order.
[5] Make only one application of diuron preplant or PRE. For resistant management apply either Valor or Reflex and not both when possible.
[6] Do not apply more than 24 oz/A of Reflex. Consider split applications of Reflex at 12 oz/A PPI plus Treflan/Prowl and Reflex at 10-12 oz/A plus diuron PRE. Incorporate Reflex no deeper than 2 inches with a field conditioner or similar implement; do not use disk.

Table 5. Managing Palmer amaranth with Ignite-based programs.[1]

Preplant or Preemergence (PRE)[2]	POST 1 (2" Palmer; 1 lf cotton)	POST 2 (2" Palmer; 6-7 lf cotton)	Layby
Conventional Tillage: 1. Diuron + Prowl 2. Cotoran + Prowl 3. Reflex + Prowl or diuron 4. Staple + Prowl or diuron	Ignite + Dual Magnum	Ignite[3]	diuron + MSMA[4]
Conservation Tillage:			
Valor preplant; Prowl + diuron or Cotoran PRE	Ignite + Dual Magnum	Ignite[3]	diuron + MSMA[4]
diuron preplant; Prowl + Reflex or Staple PRE	Ignite + Dual Magnum	Ignite	diuron + MSMA[4]

[1] Cotton must be tolerant to Ignite 280 (glufosinate) herbicide rates applied.
[2] The addition of paraquat is needed for all at-plant applications if Palmer is emerged at time of application; Roundup may be used instead if resistant Palmer is not emerged. Staple systems should be avoided if ALS-resistant Palmer amaranth is present.
[3] The addition of a residual herbicide would be beneficial; however, Dual Magnum can only be applied once and Warrant is not currently labeled for this mixture. Of labeled options, Staple would be the most effective product to provide residual pigweed control of non-resistant Palmer plants.
[4] Add an adjuvant. Will not control grasses larger than 1 in.

Glyphosate-Resistant Common Ragweed

A biotype of common ragweed resistant to glyphosate has been confirmed in North Carolina. To avoid further selection for glyphosate resistance in Georgia, Cotoran, Direx, or Reflex can be applied preemergence. Envoke can also be applied postemergence to control common ragweed, but caution should be exercised in using Envoke if Palmer amaranth is present. Ignite 280, applied to tolerant cultivars, is also effective on common ragweed.

Preserving Ignite is Critical to Our Future

Georgia growers planted a considerable amount of Phytogen WideStrike cotton in 2011 with the primary impetus being the option to use Ignite for glyphosate-resistant Palmer amaranth control. Acreage planted to LibertyLink varieties are increasing and expected to increase even more rapidly as the trait is placed into varieties that perform well agronomically. Ignite will be an important tool for cotton growers for the foreseeable future. It is imperative that growers not abuse the technology by over-dependence on Ignite. A sound resistance management strategy must be implemented in LibertyLink or WideStrike systems.

When growers obtain populations of Palmer amaranth resistant to both Roundup and Ignite, the economic sustainability of cotton production on the family farm is doubtful for our growers.

Burndown in No-Till or Strip-Till Cotton

Winter weeds should be killed at least 2 to 3 weeks before planting. Cover crops should be killed at least 1 week before planting. With cover crops a rainfall event or irrigation occurring between burndown and planting is also often needed. Recommended burndown herbicides and application rates for small grain cover crops are outlined in Appendix V.

If no-tilling or strip-tilling into natural cover (i.e., winter weeds), the need for an early burndown treatment will depend on the weed species present and the size of the weeds. An early burndown is normally advantageous, especially if ryegrass, cutleaf eveningprimrose, horseweed, wild mustard, wild radish, or curly dock is present.

Cutleaf eveningprimrose has been one of the most common and most difficult weeds to kill in strip-till or no-till fields. The most effective and economical option for cutleaf eveningprimrose is application of 2,4-D alone or mixed with glyphosate at least 30 days before planting. **The ideal and most effective time to apply 2,4-D is late February.** At this time, the suggested rate of application of 2,4-D to control cutleaf eveningprimrose is 6 to 8 fluid ounces of a 3.8 pound per gallon formulation. Use 1.0 to 1.5 pint of a 3.8 pound per gallon formulation for other weeds such as wild radish and use 1.5 to 2.0 pints of a 3.8 pound per gallon formulation for horseweed. Clarity, an option for glyphosate-resistant horseweed will also control cutleaf eveningprimrose although somewhat less effective on primrose than 2,4-D.

Growers are strongly encouraged to incorporate 2,4-D into their no-till or strip-till management programs. Cutleaf eveningprimrose is very difficult to control in emerged cotton. For growers who do not want to put 2,4-D in their sprays, Ignite or a combination of glyphosate plus Valor are options to provide fair (70 to 80%) control of pre-blooming primrose. If applying Valor, review the label for tank clean out procedures after EACH day of use.

Early control of cutleaf eveningprimrose and other weeds is recommended. However, after cutleaf eveningprimrose has begun blooming, good control can be obtained with a combination of paraquat plus Direx. This combination also is effective on most other winter weeds. Ignite 280 is also effective on blooming cutleaf eveningprimrose under warm conditions but Ignite will not control immature wild radish.

Extensive research has shown little to no benefit from application of Aim, ET, Goal, Harmony Extra, Harmony GT, or Resource to cutleaf eveningprimrose.

Wild radish can also be control by 2,4-D at 1.0 to 1.5 pt/A (of a 3.8 pound per gallon formulation) when applied alone or with 1.0 pt/A of 2,4-D when mixed with Roundup. For growers not willing to use 2,4-D, radish can be controlled very effectively by glyphosate plus Harmony type products or Express when applied at least 14 days prior to planting cotton. Once radish is fully matured (i.e. pod set), Ignite, glyphosate plus Valor, or Gramoxone plus diuron can also be used to provide good to excellent control.

Before applying any herbicide prior to cotton planting review the table below and the respective product labels for uses and plant back restrictions.

Plant back restrictions and comments for cotton burndown herbicides.

Burndown Herbicide Choice	Time Interval Before Planting	Special Comments
glyphosate	anytime prior to planting	
glyphosate + 2,4-D or 2,4-D alone	unknown for many brands of 2,4-D; 30 days for Barrage HF and Salvo 5 at proper rates	label suggest cotton can be planted after 2,4-D has dissipated from the soil
glyphosate + Harmony Extra or glyphosate + Express	at least 14 days	
glyphosate + Valor	strip-till: >7 d no-till with <30% residue: 28 d and 1 inch rain no-till with >30% residue: 21 d and 1 inch of rain	For strip tillage production with 7 d plant back: growers must apply the Valor and then follow with a strip tillage operation followed by planting; Valor application and planting must be separated by at least 7 days.
glyphosate + pendimethalin	apply within 15 days of planting	
glyphosate + Goal	at least 30 days	need 3 rainfalls each at least 0.25 inch
paraquat	any time prior to planting	
paraquat + 2,4-D	unknown for many brands of 2,4-D; 30 days for Barrage HF and Salvo 5 at proper rates	label suggest cotton can be planted after 2,4-D has dissipated from the soil
paraquat + Direx	15 to 45 days	*This label is being changed, check with the local extension office for an update.*
paraquat + Harmony Extra	at least 14 days	
paraquat + Goal	at least 30 days	need 3 rainfalls each at least 0.25 inch

Appendix V: COTTON WEED CONTROL

WEED	HERBICIDE, FORMULATION, and MODE OF ACTION CODE[1]	BROADCAST RATE/ACRE		REMARKS AND PRECAUTIONS
		AMOUNT OF FORMULATION	POUNDS ACTIVE (AI or AE)	
EARLY PREPLANT BURNDOWN				
Burndown of emerged annual weeds but does not adequately control primrose, geranium, large radish or glyphosate- resistant horseweed.	glyphosate 4.0 SL (3 lb a.e.) 5.4 SL (4 lb a.e.) 5.0 SL (4.17 lb a.e.) 5.5 SL (4.5 lb a.e.) 6.0 SL (5.0 lb a.e.) MOA 9	 32 to 48 fl oz 24 to 36 fl oz 23 to 34 fl oz 22 to 32 fl oz 19 to 29 fl oz	0.75 to 1.13 (lb a.e.)	Apply anytime prior to planting to control emerged weeds. Some formulations require additional adjuvant. Control of cover crops: Wheat < 12 in.: 0.56 lb a.e. Wheat > 12 in.: 0.75 lb a.e. Rye < 18 in.: 0.56 lb a.e. Rye >18 in.: 0.75 lb a.e.
Emerged primrose, wild radish, and spiderwort.	2,4-D amine (numerous brands) 4 L 4.7 L 5 L MOA 4	 12 to 24 fl oz 10 to 20 fl oz 9 to 18 fl oz	0.38 to 0.75	The MOST CONSISTENT and effective burndown program for winter weeds in Georgia is a 2,4-D application in February when weeds are small and herbicide coverage is adequate followed by glyphosate or paraquat at or near planting. PRIMROSE: Apply 0.18 to 0.24 lb ai/A RADISH: Apply 0.5 to 0.75 lb ai/A HORSEWEED: Apply 0.75+ lb ai/A See specific product used for cotton plant back interval.
Burndown of emerged weeds including primrose, radish, tropical spiderwort, and most other weeds. 2,4-D rates are low to control resistant horseweed.	glyphosate (numerous brands) + 2 ,4-D (numerous brands) 4 L 4.7 L 5 L MOA 9 + 4	see glyphosate + 8 to 16 fl oz 6 to 12 fl oz 6 to 11 fl oz	0.38 to 1.13 (lb a.e.) + 0.24 to 0.48	See comments for glyphosate applied alone. Most, but not all, brands of 2,4-D may be applied at least 30 days ahead of cotton planting. 2,4-D is the most effective option available for burndown of cutleaf eveningprimrose and 0.18 to 0.24 lb ae/A will control primrose. Glyphosate plus 2,4-D may not adequately control Carolina geranium. Use amine formulations of 2,4-D.
Aim improves control of emerged morningglory, tropical spiderwort, and very small (1 inch) glyphosate-resistant Palmer amaranth.	glyphosate (numerous brands) + carfentrazone (Aim) 2 EC MOA 9 + 14	see glyphosate + 0.5 to 1.0 fl oz	0.75 to 1.13 (lb a.e.) + 0.008 to 0.016	See comments for glyphosate applied alone. May be applied as a burndown treatment anytime prior to planting. Aim does not provide residual weed control.
Dicamba improves primrose, morningglory, and glyphosate- resistant horseweed control. Suppresses geranium and curly dock.	glyphosate (numerous brands) + dicamba (Clarity) 4 SL MOA 9 + 4	see glyphosate + 8 fl oz	0.75 to 1.13 (lb a.e.) + 0.25	See comments for glyphosate applied alone. Following application of dicamba AND a minimum of 1 in. of rainfall, a waiting period of at least 21 days is required before planting. Dicamba can be applied alone with little to no effect on the small grain cover crop. Dicamba is less effective than 2,4-D on primrose but more effective on horseweed.

WEED	HERBICIDE, FORMULATION, and MODE OF ACTION CODE[1]	BROADCAST RATE/ACRE		REMARKS AND PRECAUTIONS
		AMOUNT OF FORMULATION	POUNDS ACTIVE (AI or AE)	
EARLY PREPLANT BURNDOWN (continued)				
Valor improves emerged primrose and radish control. Valor at 2 oz/A provides residual control of pigweed, pusley, smallflower morningglory and other sensitive weeds for up to 6 to 8 weeks if it reaches the soil and is activated. ***Valor or diuron should be applied preplant to every acre of cotton.***	glyphosate (numerous brands) + flumioxazin (Valor SX) 51 WDG MOA 9 + 14	see glyphosate + 1 to 2 oz	0.75 to 1.13 (lb a.e.) + 0.032 to 0.063	See comments for glyphosate applied alone. In strip tillage cotton, Valor can be applied 7 to 10 days ahead of planting as long as the strip-till operation occurs between applying Valor and planting. In no-tillage production or when the strip is implemented prior to application, allow at least 30 days and 1 inch of rain prior to planting if less than 30% ground cover is present; 21 days if greater than 30% ground cover is present. Valor is less effective than 2,4-D on primrose; mixing 2,4-D at 0.125 lb ai/A with glyphosate and Valor will control primrose. Add a non-ionic surfactant or crop oil concentrate (preferred), regardless of glyphosate brand. **For PPO-resistance management, make only two applications of Reflex or Valor in two years. CAREFULLY follow label directions for cleaning out the sprayer after each days use!**
Pendimethalin does not improve control of emerged weeds but offers residual control of annual grasses and small seeded broadleaves (pigweed, pusley, etc) if it reaches the soil and is activated.	glyphosate (numerous brands) + pendimethalin (Prowl) 3.3 EC (Pendimax) 3.3 EC (Prowl H20) 3.8 AS MOA 9 + 3	see glyphosate + 1.8 to 3.6 pt 1.8 to 3.6 pt 2 to 3 pt	0.75 to 1.13 (lb a.e.) + 0.75 to 1.5 0.75 to 1.5 0.95 to 1.4	See comments for glyphosate and pendimethalin alone. Apply pendimethalin up to 15 days before planting. Pendimethalin must be activated by rainfall or irrigation, preferably within 2 days of application. Pendimethalin may delay or reduce control of large grasses, including cover crops, by glyphosate.
ET improves control of emerged morningglory and small (1 inch) glyphosate- resistant Palmer amaranth.	glyphosate (numerous brands) + pyraflufen ethyl (ET) 0.208 EC MOA 9 + 14	see glyphosate + 0.5 to 2.0 fl oz	0.75 to 1.13 (lb a.e.) + 0.0008 to 0.003	See comments for glyphosate applied alone. May be applied as a burndown treatment anytime prior to planting. ET does not provide residual weed control.
Improved control of of henbit, chickweed, and wild radish compared to glyphosate alone. Use Harmony Extra or Nimble to improve control of curly dock. 2,4-D is more effective on primrose.	glyphosate (numerous brands) + thifensulfuron + tribenuron (FirstShot SG) 50 SG MOA 9 + 2 + 2	see glyphosate + 0.5 to 0.8 oz	0.75 to 1.13 (lb a.e.) + 0.008 to 0.013 + 0.008 to 0.013	See comments for glyphosate applied alone. Apply at least 14 days prior to planting. Include nonionic surfactant at 1 to 2 qt per 100 gal spray or crop oil concentrate at 1 to 2 gal per 100 gal spray.
	glyphosate (numerous brands) + thifensulfuron + tribenuron (Harmony Extra SG with TotalSol) 50 SG (Harmony Extra, Nimble) 75 WDG MOA 9 + 2 + 2	see glyphosate + 0.75 oz 0.5 oz	0.75 to 1.13 (lb a.e.) + 0.0156 + 0.0078	
	glyphosate (numerous brands) + tribenuron (Express SG with TotalSol) 50 SG MOA 9 + 2	see glyphosate + 0.3 oz	0.75 to 1.13 (lb a.e.) + 0.009	

WEED	HERBICIDE, FORMULATION, and MODE OF ACTION CODE[1]	BROADCAST RATE/ACRE		REMARKS AND PRECAUTIONS
		AMOUNT OF FORMULATION	POUNDS ACTIVE (AI or AE)	
EARLY PREPLANT BURNDOWN (continued)				
Burndown of emerged annual weeds. Does not control immature eveningprimrose, large horseweed, curly dock, swinecress, immature radish, or large grasses.	paraquat (Gramoxone SL) 2 SL (Firestorm, Parazone) 3SL MOA 22	 2.5 to 4.0 pt 1.7 to 2.7 pt	0.63 to 1.0	Apply any time prior to planting to control emerged weeds. Add nonionic surfactant at 2 pt per 100 gal of spray mix or crop oil concentrate at 1 gal per 100 gal spray mix. **The addition of diuron is strongly encouraged.** Apply 0.63 lb ai for wheat and 0.5 lb ai for rye cover crop. Cover crops must be mature (seedheads present) for adequate control.
Burndown of emerged annual weeds and provides residual control if diuron reaches the soil and is activated. Effective on <u>mature</u> primrose and wild radish. **<u>By FAR</u>** <u>the most effective option for emerged glyphosate-resistant pigweed.</u>	paraquat (Gramoxone 2 SL) 2SL (Firestorm, Parazone) 3SL + diuron (Direx) 4 F MOA 22 + 7	 2.5 to 4.0 pt 1.7 to 2.7 pt + 1.5 to 2.0 pt	0.63 to 1.0 + 0.75 to 1.0	See comments for paraquat alone. Apply diuron 15 to 45 days ahead of planting, according to label. Do not apply on sand or loamy sand soil. Do not apply Di-Syston or Thimet in the cotton seed furrow. If Caparol, Cotoran, or diuron is applied preemergence, reduce rate to account for residual activity of diuron applied at burndown. **Add crop oil concentrate at 1 gal per 100 gal spray mix.** When mixed with crop oil concentrate and applied in May when winter weeds are mature, control is much greater than when applied on immature winter weeds.
EARLY PREPLANT BURNDOWN OF GLYPHOSATE-RESISTANT HORSEWEED				
Glyphosate-resistant horseweed.	glyphosate (numerous brands) + 2 ,4-D (numerous brands) + flumioxazin (Valor SX) 51 WDG MOA 9 + 4 + 14	see glyphosate + see label + 1 to 2 oz	0.75 to 1.13 (lb a.e.) + 0.75 to 1.0 + 0.031 to 0.063	Glyphosate-resistant horseweed is likely present in GA. Glyphosate plus 2,4-D plus Valor SX or glyphosate plus dicamba plus Valor are the **preferred treatments.** See previous comments concerning waiting intervals after applying each product. The 2,4-D or dicamba is needed in the mixture to control emerged resistant horseweed while the Valor provides residual control that may germinate after the application. **For PPO-resistance management, make only two applications of Valor or Reflex in two years.**
	glyphosate (numerous brands) + dicamba (Clarity) 4 SL + flumioxazin (Valor SX) 51 WDG MOA 9 + 4 + 14	see glyphosate + 8 fl oz + 1 to 2 oz	0.75 to 1.13 (lb a.e.) + 0.25 + 0.031 to 0.063	
	paraquat (Gramoxone Inteon) 2SL (Firestorm, Parazone) 3SL + diuron (Direx) 4 F MOA 22 + 7	 4.0 pt 2.7 pt + 1.5 to 2.0 pt	1.0 + 0.75 to 1.0	Gramoxone plus Direx can be applied 15 to 45 days ahead of planting cotton, according to label. Adjust Direx rate according to soil type. Spray when daytime temps exceed 70 F. Add 1 gal of crop oil concentrate per 100 gal. of spray solution. May add 2,4-D or Clarity to this mixture to improve control of emerged plants.
	glufosinate (Ignite 280 SL) 2.34 L MOA 10	29 to 43 lf oz	0.53 to 0.78	Ignite is recommended for fields where growers have failed to control glyphosate-resistant horseweed and cotton will be planted in less than 15 days after an application. Best results will be obtained if sprayed when daytime temperatures exceed 80 degrees farenheight. Use 15 GPA while applying with medium droplet size.

[1]Mode of Action (MOA) code can be used to delay weed resistance by increasing herbicide diversity in a management program.

WEED	HERBICIDE, FORMULATION, and MODE OF ACTION CODE[1]	BROADCAST RATE/ACRE: AMOUNT OF FORMULATION	BROADCAST RATE/ACRE: POUNDS ACTIVE (AI or AE)	REMARKS AND PRECAUTIONS
PREPLANT: AT OR JUST PRIOR TO PLANTING				
Burndown of emerged annual weeds and cover crops. Inadequate control of primrose, radish, geranium and resistant pigweed often noted.	glyphosate 4.0 SL (3 lb a.e.) 5.4 SL (4 lb a.e.) 5.0 SL (4.17 lb a.e.) 5.5 SL (4.5 lb a.e.) 6.0 SL (5.0 lb a.e.) MOA 9	 32 to 48 fl oz 24 to 36 fl oz 23 to 34 fl oz 22 to 32 fl oz 19 to 29 fl oz	0.75 to 1.13 (lb a.e.)	If an early burndown treatment was applied, apply glyphosate or paraquat in combination with desired residual herbicides at planting. Glyphosate or paraquat may be tank mixed with registered preemergence herbicides applied after planting but before cotton emerges. See suggested rates and precautions on labels of tank-mix partners. If an early burndown treatment was not used, apply glyphosate or paraquat 7 to 21 d ahead of planting. If weeds are emerged at planting, make a second application with the desired residual herbicide.
Burndown of emerged annual weeds. Does not control immature eveningprimrose, large horseweed, curly dock, swinecress, immature radish, or large grasses.	paraquat (Gramoxone SL) 2SL (Firestorm, Parazone) 3SL MOA 22	2.5 to 4.0 pt 1.7 to 2.7 pt	0.63 to 1	Glyphosate or paraquat rates depend upon weed species and size; see labels for recommended rates. Add nonionic surfactant at 2 pt per 100 gal or crop oil concentrate at 1 gal per 100 gal spray mix for paraquat. Need for adjuvants with glyphosate depend upon brand used. Control of mature cover crops: Wheat < 12 in.: glyphosate 0.56 lb a.e. or paraquat 0.63 lb Wheat > 12 in.: glyphosate 0.75 lb a.e. or paraquat 0.63 lb Rye < 18 in.: glyphosate 0.56 lb a.e. or paraquat 0.5 lb Rye > 18 in: glyphosate 0.75 lb a.e. or paraquat 0.5 lb Paraquat controls mature cover crops (visible seedheads) much more effectively than immature ones.
Burndown of mature primrose and morningglory. Inadequate control of immature radish or grain cover crops.	glufosinate-ammonium (Ignite 280 SL) 2.34 L MOA 10	29 to 43 fl oz	0.53 to 0.78	Applications may be made in fallow fields, post harvest, prior to planting or emergence of cotton. Mix with ammonium sulfate when applied for burndown. Use 15 GPA while applying with medium droplet size.
PREPLANT INCORPORATED				
Annual grasses, pigweeds, and Florida pusley. Controls glyphosate-resistant Palmer amaranth more effectively when applied preemergence.	pendimethalin (Prowl) 3.3 EC (Pendimax) 3.3 EC (Prowl H20) 3.8 AS MOA 3	 1.2 to 2.4 pt 1.2 to 2.4 pt 2 pt	 0.5 to 1 0.5 to 1 0.95	Soil incorporate 2 to 3 inches deep within 24 hours of application. Application within a week of planting is preferred. Pendimethalin is less volatile than trifluralin and is a better option if incorporation is delayed, although delayed incorporation will reduce weed control.
	trifluralin (Treflan, others) 4.0 EC MOA 3	1 to 2 pt	0.5 to 1	Soil incorporate 2 to 3 inches deep within 24 hours of application. In most situations, rate should not exceed 1.5 pt per acre. Application within a week of planting is preferred.
Glyphosate-resistant Palmer amaranth & yellow nutsedge	fomesafen (Reflex) 2 L MOA 14	16 to 24 fl oz	0.25 to 0.37	Currently a Section 2 (ee) label allows for preplant incorporated application of Reflex in Georgia. For dryland production, incorporate Reflex to a SHALLOW (2 inch or less) depth while the soil is moist. For Palmer amaranth, less control is noted with preplant incorporated applications as compared to PRE applications when activated immediately by irrigation or rainfall; less injury potential is noted with incorporated applications. Currently, a label recommending split applications of Reflex is being developed. Reflex at 12 oz/A plus Treflan/Prowl preplant incorporated followed by Reflex 10-12 oz PRE plus diuron is proving to be very effective.

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WEED	FORMULATION, and MODE OF ACTION CODE[1]	BROADCAST RATE/ACRE		REMARKS AND PRECAUTIONS
		AMOUNT OF FORMULATION	POUNDS ACTIVE (AI or AE)	
HERBICIDE, PREEMERGENCE-BROADLEAF AND GRASS CONTROL				
Most annual grasses and many annual broadleaf weeds such as prickly sida, tropic croton, smartweed and common ragweed.	clomazone (Command 3 ME) MOA 13	1.3 to 3.3 pt	0.5 to 1.25	To avoid serious crop injury, the insecticides Di-Syston, Phorate, or Thimet must be placed directly in the furrow with the seed. Off-site movement can cause visible injury (bleaching) to non-target plants. Consult the label for numerous precautions and concerns for off target movement and rotational restrictions. For improved control of Texas millet, morningglory, and pigweed, Command should be used in a program with pendimethalin or trifluralin.
Annual broadleaf weeds and suppression of annual grasses. More effective than fluometuron on pigweed, less effective on most other broadleaf weeds.	diuron (Direx, diuron) 80 DF (Direx, diuron) 4 L MOA 7	0.63 to 1.25 lb 1.0 to 2.0 pt	0.5 to 1	Apply to soil surface after planting but before crop and weeds emerge. Label suggests not use on sands or soils containing less than 1% organic matter; see label. Do not apply Di- Syston or Thimet in the cotton seed furrow. See label for use rates on your soil and rotational restrictions. May mix with pendimethalin, Reflex, or Staple. The addition of paraquat or glyphosate is needed if weeds are emerged. Rainfall needed within 7 days of application. However, heavy rains immediately following planting and diuron application can cause significant stunting and chlorosis.
Annual broadleaf weeds, suppression of annual grasses. The most effective single preemergence material for sicklepod, cocklebur, and morningglory control.	fluometuron (Cotoran) 4 F MOA 7	2 to 3 pt	1 to 1.5	Apply to soil surface after planting but before crop and weeds emerge. Do not use high rates on light silt or sandy soils; see label. May mix with pendimethalin, Reflex, or Staple. See rotational restrictions and maximum use rates on labels. The addition of paraquat or glyphosate is needed if weeds are emerged. Rainfall needed within 7 days of application. However, heavy rains immediately following planting and Cotoran application can cause significant stunting and chlorosis.
Pigweeds including glyphosate-resistant Palmer amaranth. Good control of yellow nutsedge and wild poinsettia.	fomesafen (Reflex) 2 L (Dawn) 2 L MOA 14	12 to 16 fl oz	0.19 to 0.25	Suggest mixing with Prowl, diuron, Cotoran, or Staple; apply to soil surface within 2 d of planting and irrigate within 3 d of planting. Application only to coarse-textured soils; however, on sandy soils with low organic matter, rate may need to be reduced to avoid serious injury. If conditions remain moist/wet over the cotton emerging period (irrigation or rainfall); significant necrosis and bronzing may occur. Injury may also occur in treated fields especially if heavy rains occur as cotton is emerging. Add paraquat or glyphosate for emerged weeds. Reflex will provide good pigweed control even if the first rain does not occur until 15 days after treatment. Pigweed that emerges before activation will not be controlled. **For PPO-resistance management, make only two applications of fomesafen or Valor in two years.**
Annual grasses, pigweeds, and Florida pusley.	pendimethalin (Prowl) 3.3 EC (Pendimax) 3.3 EC (Prowl H20) 3.8 AS MOA 3	1.8 to 3.6 pt 1.8 to 3.6 pt 2 to 3 pt	0.75 to 1.5 0.75 to 1.5 0.95 to 1.42	Preemergence applications are less consistent than incorporated treatments. Suggest mixing with Cotoran, Reflex or Staple. Add paraquat or glyphosate for emerged weeds. If conditions remain moist/wet over the cotton emerging period (irrigation or rainfall); significant plant stunting, leaf/stem malformation, and stem swelling may occur. In conservation tillage, suggest at least 2.5 pt/A. Apply within 2 d of planting. Irrigate within 3 d of planting.
Controls pigweeds including glyphosate-resistant Palmer amaranth, lambsquarters, prickly sida, spurge, and smartweed. Suppresses morningglory, except tall.	pyrithiobac (Staple LX) 3.2 SL MOA 2	1.7 to 2.1 fl oz	0.0425 to 0.053	Do not apply on soils with less than 0.5% organic matter. Can tank mix with diuron, fluometuron, pendimethalin, or Reflex, apply within 2 d of planting and irrigate within 3 d of planting. If conditions remain moist/wet over the cotton emerging period (irrigation or rainfall); significant plant stunting will occur. Add paraquat or glyphosate for emerged weeds. Staple will provide good pigweed control even if the first rain does not occur until 15 days after treatment. Pigweed that emerges before activation will not be controlled. **Palmer amaranth biotypes resistant to Staple are becoming common. For ALS-resistance management, make only one application of Staple and/or Envoke per season.**

[1]Mode of Action (MOA) code can be used to delay weed resistance by increasing herbicide diversity in a management program.

WEED	HERBICIDE, FORMULATION, and MODE OF ACTION CODE[1]	BROADCAST RATE/ACRE		REMARKS AND PRECAUTIONS
		AMOUNT OF FORMULATION	POUNDS ACTIVE (AI or AE)	
POSTEMERGENCE OVER-THE-TOP BROADLEAF AND GRASS CONTROL FOR ANY CULTIVAR Application of postemergence herbicide treatments to moisture stressed weeds usually results in poor control.				
Annual broadleaf weeds. **Poor control** of Palmer amaranth larger than 2 inch.	fluometuron (Cotoran) 4 F MOA 7	2 to 2.5 pt	1 to 1.25	Apply overtop of cotton 3 to 6 in. tall. Add surfactant at 1 qt per 100 gal. **Salvage treatment**. Cotton usually injured, maturity delayed, and yield can be reduced. Rates greater than 1 lb a.i. per acre not advised.
Morningglory (except tall mg), coffee senna, redweed and pigweed < 2 inches, excluding ALS resistant pigweed. Appropriate weed sizes (less than 3 inches) and favorable growing conditions are essential. Residual control of sensitive species if contacts soil and is activated.	pyrithiobac (Staple LX) 3.2 SL MOA 2	2.6 to 3.8 fl oz	0.06 to 0.09	Apply overtop of cotton from cotyledonary stage up to 60 days of harvest. Avoid applying during periods of cool, wet weather. Include nonionic surfactant at 1 qt per 100 gal spray mix. Label allows two applications per year, not exceeding a total of 5.1 fl oz. Do not mix with grass control herbicides. May tank mix with most insecticides, but do not tank mix with any product containing malathion. **Do not mix with any Dual product.** Separate Staple and Dual applications by 5 or more days. See label for rotational restrictions. **Palmer amaranth biotypes resistant to ALS inhibitors including Staple and Envoke are present in Georgia. Over dependence and poor application procedures when using these herbicides will quickly exacerbate this resistance issue. Make only one TIMELY application of Staple and/or Envoke per season .**
Annual broadleaf weeds including sicklepod, *Ipomoea* morningglory, and nutsedge. Will not control smallflower morningglory or ALS-resistant pigweed. Also provides residual control of sensitive species if contacts soil and is activated.	trifloxysulfuron (Envoke) 75 WDG MOA 2	0.1 oz	0.0047	Apply overtop after cotton has at least 6 (prefer 7) true leaves up until 60 days of harvest. Direct application on larger cotton for improved weed coverage. Add nonionic surfactant at 1 qt per 100 gal; do not use other types of adjuvants. May mix with Centric, Karate Z, Denim or Staple, see label. Do not mix with other pesticides including plant growth regulators. To avoid the potential for severe injury, do not apply to cotton under stress, such as very dry, wet, or cool conditions. Envoke may be directed to cotton 6 in. or larger at rates of 0.1 to 0.25 oz/A. See label for details and rotational restrictions. Rainfast in 3 hr. **Palmer amaranth biotypes resistant to ALS inhibitors including Envoke and Staple are present in Georgia. Over dependence and poor application procedures when using these herbicides will quickly exacerbate this resistance issue. Make only one TIMELY application of Staple and/or Envoke per season.**
Most broadleaf weeds. Poor control of tropic croton, copperleaf and ALS-resistant pigweed. Provides broadleaf residual control of sensitive species if products contact the soil and are activated.	trifloxysulfuron (Envoke) 75 WDG + pyrithiobac (Staple LX) 3.2 SL MOA 2 + 2	0.1 oz + 1.3 to 1.9 fl oz	0.0047 + 0.03 to 0.05	Apply overtop or directed after cotton has at least 6 (prefer 7) true leaves up until 60 days of harvest. Add non-ionic surfactant at 1 qt per 100 gal. spray mix. See comments and restrictions for each product applied alone. To avoid the potential for severe injury, do not apply to cotton under stress, such as very dry, wet, or cool conditions. **Palmer amaranth biotypes resistant to ALS inhibitors including Staple and Envoke are present in Georgia. Over dependence and poor application procedures when using these herbicides will quickly exacerbate this resistance issue. Make only one TIMELY application of Staple and/or Envoke per season.**

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WEED	HERBICIDE, FORMULATION, and MODE OF ACTION CODE[1]	BROADCAST RATE/ACRE: AMOUNT OF FORMULATION	BROADCAST RATE/ACRE: POUNDS ACTIVE (AI or AE)	REMARKS AND PRECAUTIONS
POSTEMERGENCE OVER-THE-TOP BROADLEAF AND GRASS CONTROL FOR LIBERTYLINK COTTON ONLY Application of postemergence herbicide treatments to moisture stressed weeds usually results in poor control.				
Largest Palmer amaranth in the field should be 3" when treated. Control of pusley and goosegrass is not consistent, use residual at-plant herbicide. In general, broadleaf weeds should be 3 inches or less and grasses no larger than 2 inch. Excellent control of morningglory including moonflower morningglory.	glufosinate-ammonium (Ignite 280 SL) 2.34 L MOA 10	29 to 43 fl oz	0.53 to 0.79	**LIBERTYLINK CULTIVARS:** Can be applied overtop or directed from cotton emergence up to early bloom. On larger cotton, directed application may give better spray coverage on weeds. Apply in a minimum of **15 GPA generating medium size spray droplets**. Do not exceed 43 fl oz/A per application. Also, do not exceed 87 fl oz per acre per season with individual applications of 29 fl oz/A or less and do not exceed 72 oz per acre per season if any individual application greater than 29 oz/A is made. Control is improved with warm temperatures, high humidity, and bright sunlight. Mixtures with residual herbicides are often needed to assist in the control of grasses, pusley, and pigweed. **For Palmer amaranth, apply at least 29 fl oz/A when the largest pigweed is 3 inches or less.** Adjuvant not needed, but ammonium sulfate may increase control in certain situations. Do not apply within 2 hr of sunset, 1 hr of sunrise, or 70 d of harvest. Rainfast in 4 hr. Postemergence grass control herbicides, such as Poast or Select, should not be mixed with Ignite.
Staple may improve emerged pigweed control (non ALS-resistant) and provides residual activity on sensitive weeds if spray contacts soil and is activated.	glufosinate-ammonium (Ignite 280 SL) 2.34 L + pyrithiobac (Staple LX) 3.2 SL MOA 10 + 2	29 to 43 fl oz + 1.3 to 1.9 fl oz	0.53 to 0.79 + 0.03 to 0.05	**LIBERTYLINK CULTIVARS:** Some leaf speckling/burn/chlorosis will likely occur. Cotton should recover quickly. Palmer should be less than 3 inches when treated. Apply in a minimum of **15 GPA generating medium size spray droplets**. Do not mix with Dual or any other metolachlor product. **Make only one TIMELY application of Staple or Envoke per season.**
Dual Magnum will provide residual control of grasses and pigweeds if spray contacts soil and is activated.	glufosinate-ammonium (Ignite 280 SL) 2.34 L + S-metolachlor (Dual Magnum) 7.62EC MOA 10 + 15	29 to 43 fl oz + 1 to 1.33 pt	0.53 to 0.79 + 0.95 to 1.27	**LIBERTYLINK CULTIVARS:** Some leaf speckling/burn will likely occur. Cotton should recover quickly rapidly. **For Palmer amaranth, apply when the largest pigweed is 3 inches or less.** Apply in a minimum of **15 GPA generating medium size spray droplets**. Do not mix with Staple. The Ignite label currently specifies Dual Magnum as the metolachlor mixture for use in Liberty Link cotton.
POSTEMERGENCE OVER-THE-TOP BROADLEAF AND GRASS CONTROL FOR PHYTOGEN WIDESTRIKE COTTON Application of postemergence herbicide treatments to moisture stressed weeds usually results in poor control.				
Glyphosate-resistant Palmer amaranth	glufosinate-ammonium (Ignite 280 SL) 2.34 L	29 fl oz	0.53	**Phytogen cultivars with the Widestrike trait** are tolerant to Ignite. Tolerance in these cultivars is not complete, and varying levels of crop injury are often noted. Greater injury can be expected when Ignite is mixed with AMS, mixed with other pesticides, or applied at higher rates. **Grower assumes the liability of crop injury.** Make no more than two topical applications with both applications being made prior to 8 leaf cotton. Apply in a minimum of **15 GPA generating medium size spray droplets**. Do not apply within 2 hr of sunset, 1 hr of sunrise, or 70 d of harvest.

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WEED	HERBICIDE, FORMULATION, and MODE OF ACTION CODE[1]	BROADCAST RATE/ACRE		REMARKS AND PRECAUTIONS
		AMOUNT OF FORMULATION	POUNDS ACTIVE (AI or AE)	
POSTEMERGENCE OVER-THE-TOP BROADLEAF AND GRASS CONTROL FOR ROUNDUP READY FLEX COTTON Application of postemergence herbicide treatments to moisture stressed weeds usually results in poor control.				
Controls most annual weeds; exceptions include glyphosate-resistant Palmer amaranth, dayflower, Florida pusley, tropical spiderwort, doveweed and hemp sesbania. Timely applications critical for purslane and morningglory. Conventional at plant and directed herbicide options must be used even in a Roundup Ready Flex program.	glyphosate 4.0 SL (3 lb a.e.) 5.4 SL (4 lb a.e.) 5.0 SL (4.17 lb a.e.) 5.5 SL (4.5 lb a.e.) 6.0 SL (5.0 lb a.e.) MOA 9	 32 to 48 fl oz 24 to 36 fl oz 23 to 34 fl oz 22 to 32 fl oz 19 to 29 fl oz	0.75 to 1.12	**ROUNDUP READY FLEX CULTIVARS** Use brands labeled for use in Roundup Ready Flex cotton." If applying a product other than Roundup WeatherMax or PowerMax refer to label for specific application rates and timings. For WeatherMax or PowerMax, they may be applied overtop or directed to Flex cotton anytime from cotton emergence until 7 days prior to harvest. The maximum rate for any single application between emergence and 60% open bolls is 32 fl oz (1.12 lb a.e.). Do not exceed a total of 128 fl oz (4.5 lb a.e.) applied from emergence through 60% open bolls. Do not exceed a maximum of 44 fl oz (1.55 lb a.e.) applied between layby and 60% open bolls. Do not exceed a maximum of 44 fl oz between 60% open bolls and harvest. Directed applications may be more effective in larger cotton to allow better coverage of weeds under canopy or to allow for tank mixes with other herbicides. **Glyphosate-resistant Palmer amaranth continues to spread rapidly. Programs including preemergence herbicides, tank mixes with glyphosate, and layby options other than glyphosate MUST be utilized.**
Compared to glyphosate alone, tank mix provides residual control of annual grasses, pigweeds including glyphosate-resistant Palmer amaranth, and tropical spiderwort if the acetochlor contacts the soil and is activated.	glyphosate (numerous brands) + acetochlor (Warrant) 3 ME MOA 9 + 15	glyphosate + 3 pt	0.75 to 1.12 + 1.125	**ROUNDUP READY FLEX CULTIVARS** Apply when cotton is completely emerged until cotton reaches first bloom. A second application may be made as long as it is directed. Do not add adjuvants and do not mix with other pesticides. Avoid heavy dew on cotton plant and extreme, hot conditions. **Glyphosate-resistant Palmer amaranth continues to spread rapidly. Programs including preemergence herbicides, tank mixes with glyphosate, and layby options other than glyphosate MUST be utilized.**

[1]Mode of Action (MOA) code can be used to delay weed resistance by increasing herbicide diversity in a management program.

WEED	HERBICIDE, FORMULATION, and MODE OF ACTION CODE[1]	BROADCAST RATE/ACRE		REMARKS AND PRECAUTIONS
		AMOUNT OF FORMULATION	POUNDS ACTIVE (AI or AE)	
POSTEMERGENCE OVER-THE-TOP BROADLEAF AND GRASS CONTROL FOR ROUNDUP READY FLEX COTTON Application of postemergence herbicide treatments to moisture stressed weeds usually results in poor control.				
Compared to glyphosate alone, tank mix provides residual control of annual grasses, pigweeds including glyphosate-resistant Palmer amaranth, doveweed, Florida pusley, and tropical spiderwort and suppression of yellow nutsedge if the metolachlor contacts the soil and is activated.	glyphosate (numerous brands) + S-metolachlor (Dual Magnum) 7.62 EC (Brawl) 7.62 EC MOA 9 + 15	glyphosate + 1 to 1.33 pt 1 to 1.33 pt	0.75 to 1.12 + 0.95 to 1.27	**ROUNDUP READY FLEX CULTIVARS** Apply when cotton is completely emerged until 100 days before harvest. Can direct to cotton until 80 days before harvest. Do not mix with Staple and do not apply within 5 d of Staple. Other metolachlor products such as Me-Too-Lachlor, Parallel PCS, Parlay, or Stalwart are available and can be sprayed during early season (see label, usually over 3 to 6" cotton). Metolachlor may not provide the same level of control as S-metolachlor when applied at the same rate, especially by 21 d after application. Do not add adjuvants and do not mix with other pesticides. Avoid dew on cotton plant and extreme, hot conditions. **Glyphosate-resistant Palmer amaranth continues to spread rapidly. Programs including preemergence herbicides, tank mixes with glyphosate, and layby options other than glyphosate MUST be utilized.**
	glyphosate + S-metolachlor (Sequence) 5.25	2.5 pt	0.7 (lb ae) + 0.94	Apply from cotyledon stage cotton to the 10 leaf stage (not to exceed 12 inches tall) of cotton. Do not harvest within 100 days of application. Do not add adjuvants and do not mix with other pesticides. Avoid dew on cotton plant and extreme, hot conditions.
Staple improves control of hemp sesbania, morningglory, tropical spiderwort, and glyphosate-resistant Palmer amaranth. Staple may also provide residual control of pigweeds, prickly sida, smartweed, spurred anoda, and velvetleaf if it contacts the soil and is activated.	glyphosate (numerous brands) + pyrithiobac (Staple LX) 3.2 SL MOA 9 + 2	glyphosate + 1.3 to 3.8 fl oz	0.75 to 1.12 + 0.03 to 0.09	**ROUNDUP READY FLEX CULTIVARS** Can apply overtop from cotton cotyledonary stage until 60 days prior to harvest. Do not mix with any Dual or metolachlor product. In fields infested with glyphosate-resistant Palmer amaranth, apply Staple at 2.6 to 3.8 fl oz when Palmer is 2 inches or less. Crop tolerance has not been fully tested with rates greater than 2.6 fl oz of Staple in mixture with glyphosate. **Palmer amaranth biotypes with resistance to glyphosate AND ALS chemistry (Staple, Envoke, etc.) have been confirmed in Georgia. This mixture will not impact Palmer amaranth if it is resistant to both glyphosate and ALS-herbicide chemistry.** **Make only one TIMELY application of Staple and/or Envoke per season.**

WEED	HERBICIDE, FORMULATION, and MODE OF ACTION CODE[1]	BROADCAST RATE/ACRE: AMOUNT OF FORMULATION	BROADCAST RATE/ACRE: POUNDS ACTIVE (AI or AE)	REMARKS AND PRECAUTIONS
POSTEMERGENCE OVER-THE-TOP BROADLEAF AND GRASS CONTROL FOR ROUNDUP READY FLEX COTTON (continued) Application of postemergence herbicide treatments to moisture stressed weeds usually results in poor control.				
Envoke will improve control of *Ipomoea* morningglory and nutsedge	glyphosate (numerous brands) + trifloxysulfuron (Envoke) 75 WDG MOA 9 + 2	glyphosate + 0.1 oz	0.75 to 1.12 + 0.0047	**ROUNDUP READY FLEX CULTIVARS** Tank mix can be applied topically from 5 leaf (preferred 7 leaf) to 12 leaf and should be directed to improve weed coverage from 12 leaf until 60 days of harvest. Rainfast in 3 hr. Try this mixture on limited acreage only as injury can be significant. **Palmer amaranth biotypes with resistance to glyphosate AND ALS chemistry (Staple, Envoke, etc.) have been confirmed in Georgia. This mixture will not impact Palmer amaranth if it is resistant to both glyphosate and ALS-herbicide chemistry.** **Make only one TIMELY application of Staple and/or Envoke per season.**
Volunteer Roundup Ready corn **in Roundup Ready Flex cotton**	glyphosate (numerous brands) + clethodim (Select) 2 EC (Select Max) 0.97 EC MOA 9 + 1	glyphosate + 4 to 8 fl oz 6 to 12 fl oz	0.75 to 1.12 + 0.06 to 0.12 0.05 to 0.09	**ROUNDUP READY FLEX CULTIVARS** See comments for glyphosate alone. For corn up to 12 in. tall, apply 4 to 6 oz of Select or 6 oz of Select Max; for corn up to 24 in. tall, apply 6 to 8 oz of Select or 9 oz of Select Max; for corn up to 36 in. tall, apply 12 oz of Select Max. Add 2.5 lb per acre ammonium sulfate or equivalent.
	glyphosate (numerous brands) + fluazifop-p-butyl (Fusilade DX) 2 EC MOA 9 + 1	glyphosate + 4 to 6 fl oz	0.75 to 1.12 + 0.06 to 0.09	**ROUNDUP READY FLEX CULTIVARS** See comments for glyphosate alone. Apply 4 oz Fusilade for corn less than 12 in. Increase rate to 6 oz for corn up to 24 in. Add 0.25% by volume of crop oil concentrate.
	glyphosate (numerous brands) + quizalofop-p-ethyl (Assure II) 0.88 EC MOA 9 + 1	glyphosate + 5 to 8 fl oz	0.75 to 1.12 + 0.03 to 0.05	**ROUNDUP READY FLEX CULTIVARS** See comments for glyphosate alone. Apply Assure at 4 oz to corn up to 12 in., 5 oz for corn up to 18 in., and 8 oz to corn up to 30 in. Add 0.125% nonionic surfactant by volume.
Volunteer Roundup Ready soybean in Roundup Ready Flex cotton	glyphosate (numerous brands) + trifloxysulfuron (Envoke) 75 WDG MOA 9 + 2	glyphosate + 0.1 oz	0.75 to 1.12 + 0.0047	**ROUNDUP READY FLEX CULTIVARS** See comments above on glyphosate plus Envoke. Cotton should be 6 (prefer 7) leaves and soybean should have no more than 4 to 5 trifoliate leaves. Not adequately effective on soybean with the STS trait. Consider the addition of Cotoran PRE at planting to improve control in the management system. **Make only one TIMELY application of Staple and/or Envoke per season.**

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WEED	HERBICIDE, FORMULATION, and MODE OF ACTION CODE[1]	BROADCAST RATE/ACRE		REMARKS AND PRECAUTIONS
		AMOUNT OF FORMULATION	POUNDS ACTIVE (AI or AE)	
POSTEMERGENCE OVER-THE-TOP GRASS CONTROL FOR ANY COTTON CULTIVAR Application of postemergence herbicide treatments to moisture stressed weeds usually results in poor control.				
Annual grasses	clethodim (Select, others) 2 EC (Select Max) 0.97 EC (TapOut) 0.97 EC MOA 1	 6 to 8 fl oz 9 to 16 fl oz 9 to 16 fl oz	 0.09 to 0.13 0.07 to 0.12 0.07 to 0.12	Apply to actively growing grasses not under drought stress. Suggested use rate varies by weed species and size; see label. Under favorable conditions, large Texas millet can be controlled. Add crop oil concentrate at 1 qt per acre for Select. To Select Max, add nonionic surfactant at 1 qt per 100 gal solution, crop oil concentrate at 1 gal per 100 gal solution, or methylated seed oil at 1 gal per 100 gal solution. Mixtures with other herbicides may reduce grass control. Do not cultivate within 7 days before or after application. A second application may be made if needed. Many generic brands of clethodim are available.
	fluazifop p-butyl (Fusilade DX) 2 EC MOA 1	8 to 12 fl oz	0.125 to 0.188	Apply to actively growing grasses not under drought stress. Suggested use rate varies by weed species and size; see label. Apply with crop oil concentrate (preferred) at 1 gal per 100 gal solution or nonionic surfactant at 1 qt per 100 gal solution. Mixtures with other herbicides may reduce grass control. Provides occasional control/suppression of bristly starbur. Do not cultivate within 7 days before or after application. A second application may be made.
	quizalofop p-ethyl (Assure II) 0.88 EC MOA 1	7 to 8 fl oz	0.05 to 0.06	Apply to actively growing grasses not under drought stress. Suggested use rate varies by weed species and size; see label. Apply with crop oil concentrate (preferred) at 1 gal per 100 gal solution or nonionic surfactant at 1 qt per 100 gal solution. Tank mixtures with other herbicides may reduce grass control. Do not cultivate within 7 days of application. A second application may be made.
	sethoxydim (Poast) 1.53 EC (Poast Plus) 1.0 EC MOA 1	 16 fl oz 24 fl oz	0.19	Apply to actively growing grasses not under drought stress. Suggested use rate varies by weed species and size; see label. Apply in 5 to 20 GPA at 40 to 60 psi. Add crop oil concentrate at 1 qt per acre. Tank mixtures with other herbicides may reduce grass control. Do not cultivate within 7 days of application. A second application may be made.

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WEED	HERBICIDE, FORMULATION, and MODE OF ACTION CODE[1]	BROADCAST RATE/ACRE		REMARKS AND PRECAUTIONS
		AMOUNT OF FORMULATION	POUNDS ACTIVE (AI or AE)	
POSTEMERGENCE OVER-THE-TOP GRASS CONTROL FOR ANY COTTON CULTIVAR (continued) Application of postemergence herbicide treatments to moisture stressed weeds usually results in poor control.				
Perennial grasses	clethodim (Select, others) 2 EC (Select Max) 0.97 EC (TapOut) 0.97 EC MOA 1	8 to 16 fl oz 12 to 32 fl oz 12 to 32 fl oz	0.13 to 0.25 0.09 to 0.24 0.09 to 0.24	Apply to actively growing johnsongrass 12 to 24 in. tall or to bermudagrass with runners up to 6 in. A second application of 8 to 16 oz of Select or 12 to 32 oz of Select Max may be applied to bermudagrass when regrowth is up to 6 in. For johnsongrass, a second application of 6 to 8 oz of Select or 9 to 24 oz of Select Max may be applied when regrowth is 6 to 18 in. Add crop oil concentrate at 1 qt per acre to Select. To Select Max, add nonionic surfactant at 1 qt per 100 gal solution, crop oil concentrate at 1 gal per 100 gal solution, or methylated seed oil at 1 gal per 100 gal solution. Do not mix with other herbicides. Do not cultivate within 7 days before or after application. Numerous generic brands of clethodim are available.
	fluazifop p-butyl (Fusilade DX) 2 EC MOA 1	10 to 12 fl oz	0.156 to 0.188	Apply when johnsongrass is 8 to 18 inches or when bermudagrass runners are 4 to 8 inches. If needed, make a second application of 8 fl oz/A when johnsongrass regrowth or new plants are 6 to 12 inches or when bermudagrass stolon (runner) regrowth or new plants are 3 to 6 inches. Apply with crop oil concentrate (preferred) at 1 gal per 100 gal solution or nonionic surfactant at 1 qt per 100 gal solution. Provides occasional control/suppression of bristly starbur. Do not mix with other herbicides. Do not cultivate within 7 days of application.
	quizalofop p-ethyl (Assure II) 0.88 EC MOA 1	10 fl oz	0.07	Apply when johnsongrass is 10 to 24 inches or bermudagrass runners are 3 to 6 inches. A second application for treating regrowth or new plants can be made with 7 fl oz per acre when johnsongrass reaches 6 to 10 inches or bermudagrass reaches 3 to 6 inches. Apply with crop oil concentrate (preferred) at 1 gal per 100 gal solution or nonionic surfactant at 1 qt per 100 gal solution. Do not mix with other herbicides. Do not cultivate within 7 days of application.
	sethoxydim (Poast) 1.53 EC (Poast Plus) 1.0 EC MOA 1	24 fl oz 36 fl oz	0.28	Apply to johnsongrass up to 25 inches and before bermudagrass runners exceed 6 inches. If regrowth occurs or new plants emerge, make a second application of 16 fl oz per acre of Poast when johnsongrass reaches 6 to 10 inches and bermudagrass reaches 3 to 6 inches. Add 1 qt of crop oil concentrate per acre. Do not tank mix with other herbicides. Do not cultivate within 7 days of application.

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WEED	HERBICIDE, FORMULATION, and MODE OF ACTION CODE[1]	BROADCAST RATE/ACRE		REMARKS AND PRECAUTIONS
		AMOUNT OF FORMULATION	POUNDS ACTIVE (AI or AE)	
POSTEMERGENCE DIRECTED- ANY COTTON CULTIVAR Application of postemergence herbicide treatments to moisture stressed weeds usually results in poor control.				
Cocklebur, very small annual grasses, and yellow nutsedge.	MSMA (several brands) 6.0 lb/gal 6.6 lb/gal MOA 17	 2.67 pt 2.5 pt	2	~~Apply as a directed spray when cotton is 3 inches tall until first bloom.~~ Label suggests not applying MSMA after first bloom. Apply with surfactant if not formulated in the product. Preplant and topical uses of MSMA are being removed.
Effective control of many broadleaf weeds and yellow nutsedge Grasses should be 1 inch or less. Also provides residual control of many weeds. **Diuron plus MSMA is the best option to control emerged glyphosate-resistant Palmer amaranth.** **Valor provides the greatest level of residual pigweed control.**	diuron (Direx, Diuron, other)4L + MSMA (several brands) 6.0 lb/gal 6.6 lb/gal MOA 7 + 17	 1.6 to 2.4 pt + 2.67 pt 2.5 pt	0.8 to 1.2 + 2.0	Apply as directed spray to cotton at least 12 inches tall. Addition of adjuvant strongly encouraged. Label prohibits use on sand or loamy sand soils, or any soils with less than 1% organic matter. Higher rates of diuron provide greater residual weed control but extended rotational concerns, see rotational restrictions. If soil type allows, use at least 2 pt/A of diuron for control of emerged Palmer amaranth. Label suggests not applying MSMA after first bloom. Aim 2 EC or ET at 0.5 to 1.0 fl oz may be added to this combination to improve control of larger morningglory and tropical spiderwort (use Aim for spiderwort). Suggest cotton be at least 18 in. tall with 3 in of bark for Aim or ET application. Do not allow combinations with Aim or ET to contact the green portion of cotton stems. The addition of S-metolachlor with diuron plus MSMA is recommended for managing tropical spiderwort. See label of S-metolachlor product used for application restrictions.
	diuron + linuron (Layby Pro) 4 L + MSMA (several brands) 6.0 lb/gal 6.6 lb/gal MOA 7 + 7 + 17	 2 pt + 2.67 pt 2.5 pt	0.5 + 0.5 + 2	Apply as a directed spray to cotton at least 18 in. tall. Add crop oil concentrate at 1 gal per 100 gal spray mix. Label prohibits use on sand or loamy sand soils, or on any soil with less than 1% organic matter. Label suggests not applying MSMA after first bloom. Aim 2 EC at 0.5 to 1.0 fl oz/acre may be added to improve control of larger morningglory. Suggest cotton have at least 3 in. of bark and be 18 inches tall for Aim application. Do not allow spray to contact green stem of cotton.
	flumioxazin (Valor SX) 51 WDG + MSMA (several brands) 6.0 lb/gal 6.6 lb/gal MOA 14 + 17	 2 oz + 2.67 pt 2.5 pt	0.064 + 2	Apply as a directed spray to cotton at least 18 in tall. Direct spray to the lower 2 inches of the cotton stem and do not contact the green portion of the cotton stem. May apply to 6 inch cotton under a hood. Add nonionic surfactant at 1 qt per 100 gal spray mix. DO NOT use crop oil concentrate, methylated seed oil, organo-silicone adjuvant, or any adjuvant containing any of these. Label suggests not applying MSMA after first bloom. IN HOODED APPLICATIONS when no contact of the cotton crop occurs: The addition of S-metolachlor is recommended for managing tropical spiderwort. See label of S-metolachlor product used for application restrictions. **For PPO-resistance management, make only two applications of Valor or Reflex in two years.**

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WEED	HERBICIDE, FORMULATION, and MODE OF ACTION CODE[1]	BROADCAST RATE/ACRE		REMARKS AND PRECAUTIONS
		AMOUNT OF FORMULATION	POUNDS ACTIVE (AI or AE)	
POSTEMERGENCE DIRECTED- ANY COTTON CULTIVAR (continued) Application of postemergence herbicide treatments to moisture stressed weeds usually results in poor control.				
Currently, the single best layby mixture for both control of emerged glyphosate-resistant Palmer amaranth and extended residual control.	diuron (Direx, Diuron, other)4L + flumioxazin (Valor SX) 51 WDG + MSMA (several brands) 6.0 lb/gal 6.6 lb/gal MOA 7 + 14 + 7	2.0 to 2.4 pt + 1 to 2 oz + 2.67 pt 2.5 pt	1 to 1.2 + 0.03 to 0.06 + 2	**See restrictions for each product applied alone**. Cotton should be at least 20 in tall. Apply as directed spray to the lower 2 inches of the cotton stem. Experiment with this mixture on limited acreage as crop injury is of some concern. Valor may not improve control of emerged plants but will provide excellent residual control. Add nonionic surfactant at 1 qt per 100 gal spray mix. DO NOT use crop oil concentrate, methylated seed oil, organo-silicone adjuvant, or any adjuvant containing any of these. Label suggests not applying MSMA after first bloom.
Effective control of many broadleaf weeds, yellow nutsedge, and small annual grasses. Also provides residual control of many weeds.	fluometuron (Cotoran) 4 F + MSMA (several brands) 6.0 lb/gal 6.6 lb/gal MOA 7 + 17	2.0 to 3.2 pt + 2.67 pt 2.5 pt	1 to 1.6 + 2	Apply as a directed spray to cotton at least 3 in. tall. Do not apply after first bloom. The addition of S-metolachlor is recommended for managing tropical spiderwort and Palmer. See label of S-metolachlor product used for application restrictions. Not as effective as diuron + MSMA on emerged pigweed.
Emerged broadleaf weeds, yellow nutsedge, and very small annual grasses.	lactofen (Cobra) 2 EC + MSMA (several brands) 6.6 lb/gal MOA 14 + 17	6 to 12.5 fl oz + 2.5 pt	0.092 to 0.2 + 2.0	Apply as directed spray or with hoods after cotton is at least 8 in. tall, preferably at least 12 inches. Contact only lower woody portion of cotton stem. Add crop oil or nonionic surfactant according to labels. Label suggests not applying MSMA after first bloom. Do not apply lactofen within 70 days of harvest. Not as effective as diuron + MSMA on emerged pigweed.
Effective control of many broadleaf weeds, yellow nutsedge, and small annual grasses. Limited residual control.	linuron (Linex) 4 L + MSMA 6.0 lb/gal 6.6 lb/gal MOA 7 + 17	2 pt + 2.67 2.5	1 + 2	Apply as directed spray to cotton that is at least 20 inches tall. See precautions on label. Add 2 qt nonionic surfactant per 100 gal spray solution. Label suggests not applying MSMA after first bloom. Any crop may be planted 4 months after application except for cereals OTHER THAN barley, oats, rye, and wheat.
Effective control of many broadleaf weeds, yellow nutsedge, and small annual grasses. Limited residual control especially on pigweeds.	prometryn (Caparol) 4 F + MSMA (several brands) 6.0 lb/gal 6.6 lb/gal MOA 5 + 17	1.3 to 2.4 pt + 2.67 pt 2.5 pt	0.65 to 1.2 + 2	Apply as directed spray. Use 1.3 pt/A Caparol in 8 to 12 in. cotton and up to 2.4 pt/A in cotton at least 12 in. Add nonionic surfactant at 2 qt per 100 gal spray solution. See label for rotational restrictions. Label suggests not applying MSMA after first bloom. Aim 2 EC at 0.5 to 1.0 fl oz or Cobra at 6 to 8 fl oz per acre may be added to this combination to improve control of large morninglory. Cotton should be at least 18 in. tall for Aim application. DO NOT allow combinations with Aim to contact the green portion of the cotton stems. The addition of S-metolachlor with prometryn plus MSMA is recommended for managing tropical spiderwort. See label of S-metolachlor product used for application restrictions. Not as effective as diuron + MSMA on emerged pigweed.

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WEED	HERBICIDE, FORMULATION, and MODE OF ACTION CODE[1]	BROADCAST RATE/ACRE		REMARKS AND PRECAUTIONS
		AMOUNT OF FORMULATION	POUNDS ACTIVE (AI or AE)	
POSTEMERGENCE DIRECTED- ANY COTTON CULTIVAR (continued) Application of postemergence herbicide treatments to moisture stressed weeds usually results in poor control.				
Effective control of many broadleaf weeds, yellow nutsedge, and small annual grasses. Excellent residual control of sensitive species.	prometryn + trifloxysulfuron (Suprend) 80 WDG + MSMA (several brands) 6.0 lb/gal 6.6 lb/gal MOA 5 + 2+ 17	 1 to 1.25 lb + 2.67 pt 2.5 pt	0.8 to 1 + 0.007 to 0.009 + 2	Apply as directed spray in cotton at least 8 in tall. Add nonionic surfactant at 1 qt per 100 gal spray mix. See rotation restrictions on label. Label suggests not applying MSMA after first bloom. Do not exceed 0.0188 lb a.i./acre per year of trifloxysulfuron from the combined use of Envoke and Suprend. Suprend is formulated as 79.3% prometryn plus 0.7% trifloxysulfuron.
Does NOT control emerged weeds. Provides residual control of annual grasses and several small seeded broadleaf weeds if contacts the soil and is activated.	pendimethalin (Prowl) 3.3 EC (Pendimax) 3.3 EC (Prowl H20) 3.8 AS MOA 3	 1.8 to 2.4 pt 1.8 to 2.4 pt 2.0 pt	 0.75 to 1.0 0.75 to 1.0 0.95	Do NOT spray overtop of cotton. <u>Apply as a directed layby spray only.</u> Apply after controlling existing weeds. Alternatively, may mix with glyphosate in Roundup Ready cotton. All glyphosate brands not labeled for this use, see label. Apply at least 60 days prior to harvest.
POSTEMERGENCE DIRECTED- ROUNDUP READY FLEX CULTIVARS ONLY Application of postemergence herbicide treatments to moisture stressed weeds usually results in poor control.				
Controls most annual weeds; exceptions include glyphosate-resistant Palmer amaranth, dayflower, doveweed, Florida pusley, tropical spiderwort, and hemp sesbania. Timely application is critical for controlling morningglory and purslane.	glyphosate 4.0 SL (3 lb a.e.) 5.4 SL (4 lb a.e.) 5.0 SL (4.17 lb a.e.) 5.5 SL (4.5 lb a.e.) 6.0 SL (5.0 lb a.e.) MOA 9	 32 to 48 fl oz 24 to 36 fl oz 23 to 34 fl oz 22 to 32 fl oz 19 to 29 fl oz	0.75 to 1.12	**ROUNDUP READY <u>FLEX</u> CULTIVARS** Glyphosate alone can be directed to Flex cotton up to 7 days prior to harvest. When using glyphosate alone, contact with the Flex cotton plants is not of concern; the primary reason to direct is to obtain better coverage of weeds under the crop canopy. At layby, conventional herbicide chemistry is suggested. However, if one choices to use glyphosate then other herbicides, in addition to glyphosate, are recommended to aid in resistance management and to improve weed control. **Glyphosate-resistant Palmer amaranth continues to spread rapidly. Programs including preemergence herbicides, tank mixes with glyphosate, and layby options other than glyphosate MUST be utilized.**

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WEED	HERBICIDE, FORMULATION, and MODE OF ACTION CODE[1]	BROADCAST RATE/ACRE		REMARKS AND PRECAUTIONS
		AMOUNT OF FORMULATION	POUNDS ACTIVE (AI or AE)	
POSTEMERGENCE DIRECTED- ROUNDUP READY FLEX CULTIVARS ONLY (continued) Application of postemergence herbicide treatments to moisture stressed weeds usually results in poor control.				
Mixture improves control of larger morningglory and tropical spiderwort. Provides no residual weed control.	glyphosate (numerous brands) + carfentrazone (Aim EC) 2 EC MOA 9 + 14	glyphosate + 0.8 to 1.6 fl oz	0.75 to 1.12 (lb a.e.) + 0.013 to 0.025	**ROUNDUP READY FLEX CULTIVARS** ~~Cotton should be at least 18 in. tall.~~ Extreme care should be exercised in application; see directions and precautions on the Aim label. Contact on green stem will lead to severe injury. Avoid contact of the spray with desirable vegetation. See remarks for glyphosate applied alone.
Mixture improves morningglory and glyphosate-resistant Palmer amaranth control and provides residual control of small- seeded broadleaf weeds, such as pigweed. The tank mix may give less grass control than glyphosate alone.	glyphosate (numerous brands) + diuron (Direx, Diuron) 4 L MOA 9 + 14	glyphosate + 1 to 1.5 pt	0.75 to 1.12 (lb a.e.) + 0.5 to 0.75	**ROUNDUP READY FLEX CULTIVARS** Use 1 pt of Direx or diuron on cotton 8 to 12 inches and up to 1.5 pt of diuron on cotton greater than 12 inches. See comments for glyphosate applied alone. Add surfactant according to the label of the glyphosate brand used. DO NOT reduce the rate of glyphosate because of the potential for antagonism. See diuron rotational restrictions.
Mixture improves morningglory and tropical spiderwort control and provides residual control of broadleaf weeds including pigweeds, purslane, and Florida pusley. Poor control of glyphosate-resistant Palmer amaranth.	glyphosate (numerous brands) + flumioxazin (Valor SX) 51 WDG MOA 9 + 14	glyphosate + 1 to 2 oz	0.75 to 1.12 (lb a.e.) + 0.031 to 0.063	**ROUNDUP READY FLEX CULTIVARS** Cotton should be at least 18 inches. Direct spray to the lower 2 inches of cotton stem; minimize cotton contact. Do not allow spray to contact green portion of stem. Add nonionic surfactant at 1 qt per 100 gal spray mix if glyphosate brand requires adjuvant. DO NOT use crop oil concentrate, methylated seed oil, organo-silicone adjuvants, or any adjuvant product containing these. See comments for glyphosate applied alone.
Mixture improves morningglory control and provides residual control of sensitive species. The tank mix may give less grass control than glyphosate alone.	glyphosate (numerous brands) + prometryn (Caparol) 4 F MOA 9 + 5	glyphosate + 1 to 2 pt	0.75 to 1.12 (lb a.e.) + 0.5 to 1	**ROUNDUP READY FLEX CULTIVARS** Cotton should be at least 8 inch for Caparol rate between 1 and 1.3 pt and at least 12 inch for Caparol rate above 1.3 pt. Add surfactant according to the label of the glyphosate brand used. See comments for glyphosate applied alone. DO NOT reduce the rate of glyphosate because of the potential for antagonism.
Mixture improves control of larger morningglory. Will provide no residual weed control.	glyphosate (numerous brands) + pyraflufen ethyl (ET) 0.208 L MOA 9 + 14	glyphosate + 0.5 to 1.0 fl oz	0.75 to 1.12 (lb a.e.) + 0.0008 to 0.0016	**ROUNDUP READY FLEX CULTIVARS** <u>Cotton should be at least 18 in. tall.</u> Exercise extreme care with this application; see directions and precautions on the ET label. Contact on green stem will lead to severe injury. Avoid contact of the spray with desirable vegetation. See remarks for glyphosate applied alone.

[1]Mode of Action (MOA) code can be used to delay weed resistance by increasing herbicide diversity in a management program.

WEED	HERBICIDE, FORMULATION, and MODE OF ACTION CODE[1]	BROADCAST RATE/ACRE		REMARKS AND PRECAUTIONS
		AMOUNT OF FORMULATION	POUNDS ACTIVE (AI or AE)	
POSTEMERGENCE DIRECTED- ROUNDUP READY FLEX CULTIVARS ONLY (continued) Application of postemergence herbicide treatments to moisture stressed weeds usually results in poor control.				
S-metolachlor does not improve control of emerged weeds, but can give residual control of annual grasses, pigweed species, doveweed, tropical spiderwort and other dayflower species plus suppression of yellow nutsedge.	glyphosate (numerous brands) + S-metolachlor (Dual Magnum) 7.62EC (Brawl) 7.62 EC MOA 9 + 15	glyphosate + 1 to 1.33 pt 1 to 1.33 pt	0.75 to 1.12 (lb a.e.) + 0.95 to 1.27	**ROUNDUP READY FLEX CULTIVARS** Can be applied to cotton 3 in. tall through 80 days prior to harvest. Do not apply to sands or loamy sand soils. See comments for glyphosate applied alone. Use only brands registered for this application. No generic formulation of metolachlor is currently labeled for this use. Metolachlor products may not provide the same length of control as similar rates of S-metolachlor products such as Dual Magnum.
	glyphosate + S-metolachlor (Sequence) 5.25 L MOA 9 + 15	glyphosate + 2.5 pt	0.70 (lb a.e.) + 0.94	**ROUNDUP READY FLEX CULTIVARS** Direct to cotton up to 12 in. tall and minimize contact with the cotton stems and leaves. Do not add adjuvants or mix with any other product.
Mixing Envoke with glyphosate improves *Ipomoea* morningglory and nutsedge control and provides some residual control of sensitive species.	glyphosate (numerous brands) + trifloxysulfuron (Envoke) 75 DF MOA 9 + 2	glyphosate + 0.1 to 0.2 oz	0.75 to 1.12 (lb a.e.) + 0.005 to 0.009	**ROUNDUP READY FLEX CULTIVARS** Direct to cotton from 6 in tall through layby and minimize contact with cotton stems and leaves. Add nonionic surfactant according to Envoke label. See comments for glyphosate applied alone. **Palmer amaranth biotypes with resistance to glyphosate AND ALS chemistry (Staple, Envoke, etc.) have been confirmed in Georgia. This mixture will not impact Palmer amaranth if it is resistant to both glyphosate and ALS-herbicide chemistry.**
Mixing Suprend with glyphosate improves control of morningglory, pigweeds, and nutsedge. Also provides residual weed control of sensitive species.	glyphosate (numerous brands) + prometyrn + trifloxysulfuron (Suprend) 80 WDG MOA 9 + 5 + 2	glyphosate + 1 to 1.25 lb	0.75 to 1.12 (lb a.e.) + 0.8 to 0.1 + 0.007 to 0.009	**ROUNDUP READY FLEX CULTIVARS** Direct to cotton from 6 in tall. Add surfactant according to label of glyphosate brand used. See precautions and rotational restrictions on Suprend label.
Warrant does not improve control of emerged weeds, but can give residual control of annual grasses, pigweeds, and tropical spiderwort.	glyphosate (numerous brands) + acetochlor (Warrant) 3.0 ME MOA 9 + 15	glyphosate + 3 pt	0.75 to 1.12 (lb a.e.) + 1.125	**ROUNDUP READY FLEX CULTIVARS** Can be directed to cotton up to first bloom. Add surfactant according to label of glyphosate brand used. See comments for glyphosate applied alone.

[1]Mode of Action (MOA) code can be used to delay weed resistance by increasing herbicide diversity in a management program.

WEED	HERBICIDE, FORMULATION, and MODE OF ACTION CODE[1]	BROADCAST RATE/ACRE		REMARKS AND PRECAUTIONS
		AMOUNT OF FORMULATION	POUNDS ACTIVE (AI or AE)	
POSTEMERGENCE-HOODED SPRAYER				
Controls most annual weeds; exceptions include glyphosate-resistant Palmer amaranth, dayflower, doveweed, Florida pusley, tropical spiderwort, and hemp sesbania. Timely application is critical for controlling morningglory and purslane.	glyphosate 4.0 SL (3 lb a.e.) 5.4 SL (4 lb a.e.) 5.0 SL (4.17 lb a.e.) 5.5 SL (4.5 lb a.e.) 6.0 SL (5.0 lb a.e.) MOA 9	 32 fl oz 24 fl oz 23 fl oz 22 fl oz 19 fl oz	0.75 (lb a.e.)	For perennial weeds, increase rate according to label. In non-Roundup Ready cotton, hoods should be kept as close to the ground as possible. Do not allow the spray to contact stems or foliage of non-Roundup Ready cotton. Apply in 5 to 10 GPA at a maximum of 25 PSI. Do not exceed 5 MPH. Suggest that cotton be at least 8 inches tall. Glyphosate is especially effective for prostrate, running species such as citron, burgherkin, and annual grasses. See label of brand used for adjuvant recommendations and use of ammonium sulfate. Other herbicides such as Aim, Caparol, diuron, ET, or Valor may be mixed with certain glyphosate formulations to improve burndown in larger cotton. Caparol, Valor or diuron will also offer residual weed control for several troublesome weeds. Grass control may be reduced with tank mixes of glyphosate plus Caparol or diuron. **Glyphosate-resistant Palmer amaranth continues to spread rapidly. Programs including preemergence herbicides, tank mixes with glyphosate, and layby options other than glyphosate MUST be utilized.**
Annual grass and broadleaf weeds; suppression of nutsedge. *Mixtures with diuron would be the most effective option to control emerged pigweed in row middles.*	paraquat (Gramoxone SL) 2 SL MOA 22	19 to 38 fl oz	0.3 to 0.6	DO NOT CONTACT COTTON STEMS OR FOLIAGE. Apply in a minimum 15 GPA at a maximum of 25 PSI. Do not exceed 5 MPH. Hoods should be kept as close to the ground as possible. Cotton should be at least 8 inches. Add nonionic surfactant at 2 pt per 100 gal. of spray mix or crop oil concentrate at 1 gal. per 100 gal spray mix. Caparol or diuron (Direx, diuron) may be mixed with paraquat. Tank mixes are usually more effective.
Largest Palmer in field should be no more than 3" when treated. In general, broadleaf weeds should be 3 inches or less and grasses no larger than 2 inch. Excellent control of morningglory including moonflower morningglory. Diuron plus MSMA is more effective than Ignite or Ignite mixtures in controlling Palmer.	glufosinate-ammonium (Ignite 280 SL) 2.34 L MOA 10	29 to 43 fl oz	0.53 to 0.78	DO NOT CONTACT COTTON STEMS OR FOLIAGE IN NON-LIBERTYLINK OR WIDESTRIKE COTTON. Hoods should be kept as close to ground as possible. Suggest cotton be at least 8 inches. Adjuvant not needed, but ammonium sulfate may increase control in certain situations. Do not apply within 2 hours of sunset or 1 hr of sunrise. Rainfast in 4 hours. Control is improved with warm temperatures, high humidity, and bright sunlight. Mixtures with residual herbicides are often needed to assist in the control of grasses, pusley, and pigweed. Apply in a minimum of **15 GPA generating medium size droplets**. Do not exceed 5 MPH.

[1]Mode of Action (MOA) code can be used to delay weed resistance by increasing herbicide diversity in a management program.

WEED	HERBICIDE, FORMULATION, and MODE OF ACTION CODE[1]	BROADCAST RATE/ACRE		REMARKS AND PRECAUTIONS
		AMOUNT OF FORMULATION	POUNDS ACTIVE (AI or AE)	
POSTEMERGENCE-ROPE WICK, WIPER APPLICATOR				
Certain weeds taller than crop, especially non glyphosate-resistant pigweeds and grasses.	glyphosate (numerous brands and recommended rates) MOA 9	Rope or Sponge Wick: solutions of 33 to 75% glyphosate plus 67 to 25% water may be used Panel Applicators : solution ranging from 33 to 100% may be used		Check specific labels for this use of glyphosate; all products are not labeled and may suggest specific directions. Do not operate in excess of 2 MPH. Best results occur with 2 passes, the second pass in the opposite direction. Consult product label for adjuvant recommendations. **Glyphosate-resistant Palmer amaranth continues to spread rapidly. Programs including preemergence herbicides, tank mixes with glyphosate, and layby options other than glyphosate MUST be utilized.**
HARVEST AID				
Mature morningglory	carfentrazone-ethyl (Aim) 2 EC MOA 14	0.75 to 1.5 fl oz	0.012 to 0.024	Apply as a harvest aid when 60 to 70% of the cotton bolls are open AND when the morningglory are mature (seedpods are visible). May be an additive with other defoliants – see label. See label for addition of adjuvant. See cotton defoliation section.
Mature morningglory	pyraflufen ethyl (ET) 0.208 EC MOA 14	1.5 to 2.75 fl oz	0.0024 to 0.0044	Apply as a harvest aid when 60 to 70% of the cotton bolls are open AND when the morningglory are mature (seedpods are visible). May be an additive with other defoliants – see label. See label for addition of adjuvant. See cotton defoliation section.
Desiccation of most weeds. Regrowth of many weeds occurs soon after application.	paraquat (Gramoxone Inteon) 2SL MOA 22	16 to 32 fl oz	0.25 to 0.5	Defoliate cotton as normal. After at least 75% of bolls are open, the remainder of bolls expected to harvest are mature, and most of the cotton leaves have dropped, apply paraquat in a minimum of 20 GPA. Add nonionic surfactant at 1 pt per 100 gal spray mix. Wait 3 to 5 days and pick the cotton as soon as possible. Expect additional trash. An additional option is to add 2 to 6 oz of Gramoxone Inteon with standard defoliation mixtures. Be aware of potential pine tree injury with drift. Generic brands of paraquat containing 3 lb active per gallon may be labeled. These products would be applied at 11 to 21 fl oz for 0.25 to 0.5 lb active equivalent. See cotton defoliation section.
Annual grasses and broadleaf weeds	glyphosate 4.0 SL (3 lb a.e.) 5.4 SL (4 lb a.e.) 5.0 SL (4.17 lb a.e.) 5.5 SL (4.5 lb a.e.) 6.0 SL (5.0 lb a.e.) MOA 9	 32 to 64 fl oz 24 to 48 fl oz 23 to 46 fl oz 22 to 44 fl oz 19 to 38 fl oz	0.75 to 1.5 (lb a.e.)	Use only brand labeled for this use. Apply after at least 60% of bolls are open in non-Roundup Ready cotton. May be tank mixed with defoliants. See label and defoliant section. Include nonionic surfactant according to the label of glyphosate brand used. May apply in Roundup Ready Flex cotton up to 7 days before harvest. See cotton defoliation section.

[1]Mode of Action (MOA) code can be used to delay weed resistance by increasing herbicide diversity in a management program.

Appendix VI. WEED RESPONSE TO BURNDOWN HERBICIDES USED IN COTTON

Weed Species	Burndown Treatment [1]									
	2,4-D [3]	glyphosate	glyphosate acid [2] + 2,4-D [3]	glyphosate acid [2] + Clarity [4]	glyphosate acid [2] + Aim or ET	glyphosate acid [2] + diuron [*,7]	glyphosate acid [2] + Harmony Extra [5]	glyphosate acid [2] + Valor SX [6]	paraquat	paraquat + Direx [7]
GRASSES / SEDGES										
annual bluegrass	N	E	E	E	E	E	E	E	G-E	E
bermudagrass	N	F	F	F	F	F	F	F	P	P
crabgrass	N	E	G-E	G-E	E	G	E	E	F-G	G
goosegrass	N	E	G-E	G-E	E	G	E	E	F-G	G
Italian ryegrass	N	G	G	G	G	F	G	G	F	F-G
johnsongrass	N	G-E	G	G	G-E	F-G	G-E	G-E	P	P
little barley	N	E	E	E	E	E	E	E	G	G-E
sandbur	N	E	G-E	G-E	E	G	E	E	G	G
Texas panicum	N	E	G-E	G-E	E	G	E	E	G	G-E
volunteer corn (not RR vol.corn)	N	E	E	E	E	E	E	E	F-G	F-G
purple nutsedge	N	F-G	F-G	F-G	F-G	F-G	F-G	G	P-F	P-F
yellow nutsedge	N	P-F	P-F	P-F	P-F	F	P-F	F	P-F	P-F
BROADLEAVES										
bristly starbur	G	E	E	E	E	E	E	E	E	E
buttercup	G	G-E	E	E	G-E	G-E	G-E	G-E	E	E
Carolina geranium	F	P-F	F-G	G	F-G	G	G-E	G	G-E	E
chickweed	P	E	E	E	E	E	E	E	E	E
citronmelon	F	G-E	E	E	E	G-E	G-E	E	F	G
cocklebur	E	E	E	E	E	E	E	E	G-E	E
coffee senna	G	E	E	E	E	E	E	E	F	G
corn spurry	P-F	G-E	G-E			G-E			F-G	G-E
cowpea	G	E			E	E			E	E
cudweed	P	G-E	E	E		E	E	E	F-G	G
curly dock	P-F	F	F-G	G-E	F	P-F	E	F	N-P	P
cutleaf primrose	E	P-F	E	G	F	F-G	F	F-G	F[8]	G-E[8]
eclipta	P	G-E			G-E	G-E			F	F
Florida beggarweed	P-F	E	E	E	E	E	E	E	E	E
Florida pusley	F	F	G	G	G	F-G	F	F-G	F	F-G
field pansy	P-F	F	F-G	F-G			F	G	G	G-E
hemp sesbania	G-E	P-F	E		G-E	F-G			F	F-G
henbit	P-F	G-E	E	E	E	E	E	E	G-E	E

WEED RESPONSE TO BURNDOWN HERBICIDES USED IN COTTON (continued)

Weed Species	Burndown Treatment [1]									
	2,4-D [3]	glyphosate acid	glyphosate acid [2] + 2,4-D [3]	glyphosate acid [2] + Clarity [4]	glyphosate acid [2] + Aim or ET	glyphosate acid [2] + diuron [*,7]	glyphosate acid [2] + Harmony Extra [5]	glyphosate acid [2] + Valor SX [6]	paraquat	paraquat + Direx [7]
horsenettle	F	F	F-G		P-F	F			P-F	F
horseweed	G-E [9]	G-E [10]	E [10]	E [10]	G-E [10]	G-E [10]	G-E [10]	G-E [10]	P-F	F-G
lambsquarters	E	G	E	E	G-E	G-E			F-G	G
morningglory, *Ipomoea*	G-E	F	E	E	E	G		E	F-G	G
morningglory, smallflower	F-G	G	E	E	G-E	G-E		E	P	F-G
Palmer amaranth	F [9]	E	E	E	E	E	E	E	F-G	G-E
Palmer amaranth (glyphosate-resistant)	F [9]	N	F [9]	F	P-F	F		P-F	F-G	G-E
Pennsylvania smartweed	F	G	G	E	G-E	F	E		P-F	F-G
prickly sida	F-G	F-G	G	E	F-G	F-G			P-F	F-G
purslane	G-E	F	G-E	E	F-G	G		G	G	G-E
ragweed	E	G	E	E	G-E	G			G	G
redweed	F	G		G-E	G-E	G			F	G
shepherdspurse	G	G			G	G			G	G
sicklepod	F-G	G-E	E	E	G-E	E	G-E	E	E	E
speedwell	P-F	E	E	E	E	E	E	E	G	E
spurred anoda	F-G	G			G	G			F-G	F-G
swinecress	F	F-G	G	F-G	F-G	G	G-E	F-G	P-F	F-G
tropic croton	F	G-E	G-E	G-E	G-E	G-E		E	F	F-G
tropical spiderwort	G-E	P	G-E	P-F	Aim = G-E ET = P-F	F		G	G	G-E
velvetleaf	F-G	G			E	G			P	P
vines (maypop, trumpet creeper)	F	P-F			P-F	F			P	P
Virginia pepperweed	G-E	G	E	G-E	G	G	G	G-E	G	G
volunteer peanuts	P	F	F	F-G	F-G	F-G	F	F-G	P	P-F
wild lettuce	G	G-E	G-E	G-E	G-E	G-E	G-E	E	P	F
wild poinsettia	F-G	G			G-E	G-E			G-E	G-E
wild radish	G	F-G	E	G-E	G	G	E	G	F-G	G-E
COVER CROPS										
clover	F	F	F-G	F-G	F	F-G			F-G	G-E
lupine	G	G	G		G	G			F-G	F-G
small grains	N	E	E	E	E	F-G	E	E	G [11]	G-E [11]
vetch	G-E	F	E	E	F	F-G	G	F-G	P-F [8]	F-G [8]

Key**:** E = 90% or better control; G = 80% to 90% control; F = 60% to 80% control; P = 30% to 60% control; N = < 30% control.

*Diuron mixed with glyphosate can reduce the control of small grain cover crops, thus, this mixture is not recommended.

[1]Application rates per acre: Clarity: 0.5 pt; 2,4-D: 1 pt; Aim: 1 oz; ET: 1-2 oz; diuron: 0.5 to 1.0 lb a.i.; glyphosate acid: 0.75 to 1.12 lb a.e.; paraquat: 0.75 to 1.0 lb a.i.; Harmony Extra TotalSol: 0.75 oz; Valor: 1 to 2 oz.

[2]Mixing herbicides with glyphosate occasionally reduces grass control (including covercrops). This is more likely with large weeds in dry conditions.

[3]Labels for 2,4-D are ambiguous concerning the waiting period between application and planting, see label of specific brand used.

[4]Following application of Clarity and a minimum of 1 inch of rainfall, a minimum 21-day waiting period before planting is required.

[5]Harmony Extra, Nimble, or Express should be applied at least 14 days prior to planting.

[6]Delay cotton plating at least 7 days. Strip-till operation must be preformed after applying Valor but before planting.

[7]Direx should be applied 15 to 45 days ahead of planting according to the current label.

[8]This level of control requires plants to be in full bloom with seed forming when treated.

[9]This level of control requires 1.5 to 2 pt of 2,4-D (4 lb a.i. product).

[10]Glyphosate resistant horseweed is likely present in some areas, glyphosate will not control glyphosate-resistant horseweed.

[11]Small grain must have visible seedheads for this level of control.

Note: Ratings based upon average to good soil and weather conditions for herbicide performance and upon proper application rate, technique, and timing.

WEED RESPONSE TO HERBICIDES USED IN COTTON

A. Stanley Culpepper, Extension Agronomist-Weed Science

	Preplant Incorporated		Preemergence						Residual Control by POST Applied Herbicides (Assuming soil contact)		
Weed Species	**Prowl**	**Treflan others**	**Prowl[1]**	**Com-mand**	**Cotoran others**	**Direx others**	**Reflex**	**Staple**	**Dual Magnum**	**Staple**	**Envoke**
Perennials bermudagrass	N	N	N	P-F	N	N	N	N	N	N	N
johnsongrass (rhizome)	P	P	P	N	N	N		N	P	N	N
yellow nutsedge	N	N	N	N	N	N	G-E	F	F	P-F	
purple nutsedge	N	N	N	N	N	N	P-F	F	P	F	
Annual Grasses broadleaf signalgrass	G	G	F	E	P	P	F-G	P	F-G	P	P
crabgrass	E	E	G	E	F-G	F-G	F-G	P	E	P	P
crowfootgrass	E	E	G	G	F-G	F-G		P	E		P
fall panicum	G	G	F-G	G-E	F	P		P-F	G	P-F	P
foxtails	E	E	G	E	F-G			P	E	P	P
goosegrass	E	E	G	E	F	F		P-F	E	P-F	P
johnsongrass (seedling)	E	E	G	G	P	P		F-G	F	F	P
sandbur	E	E	G	F-G	G	G			F-G		P
Texas panicum	G	G	F	F	P	P	F	N	P-F	N	P
Annual Broadleaves bristly starbur	N	N	N	P	G-E	F-G	G-E	F-G	P	G	G-E
burgherkin	N	N	N	P	F-G	F		F-G	P	F-G	
citronmelon	N	N	N	P	F-G	F		F-G	P	F-G	
cocklebur	N	N	N	F	F-G	F	G	N-P	P	N-P	
coffee senna	N	N	N	P	F-G	F	N	G	P	G	
cowpea	N	N	N	N-P	P	P		F-G	P	F-G	
crotalaria	N	N	N		G	G			P		
eclipta	P	P	P		G	G	G-E		P-F		
Florida beggarweed	P	P	P	F-G	G-E	G	P	G	P-F	G	F-G
Florida pusley	E	E	F-G	F-G	F-G	P-F	P	F	G	F	P-F
hemp sesbania	N	N	N	F	P	P	P	P	P	P	
jimsonweed	N	N	N	G	G	G		F-G		F-G	
lambsquarters	G-E	G-E	G	G	G-E	G-E	E	G	F	G	
morningglories											
Ipomoea	P	P	P	P-F[2]	G	F	P-F	F[3]	P	F[3]	
smallflower	P	P	P	P	G-E	G	G-E	E	P	E	P-F
Palmer amaranth	F-G	F-G	P-F	N-P	F	G	E	G-E[3]	G	G-E[3]	P-F
pigweeds: redroot or smooth	G-E	G-E	F-G	P	G-E	G-E	E	E	G-E	G-E	F
prickly sida	N	N	N	E	G	F		G	F	G	
purslane	E	E	G	G-E	E	E	G	G	G	G	
ragweed	N	N	N	G	E	G	G	N-P	P	N-P	
redweed	N	N	N	G-E	E	G-E		G-E		G-E	
smartweed:											
ladysthumb	N	N	N	N	G	G		G		G	
Pennsylvania	N	N	N	E	G	G		G		G	
sicklepod	N	N	N	P	G	F	P	P-F	P	P	P-F
spurge	N	N	N	N	P-F	F		G	P-F	G	
tropic croton	N	N	N	E	F-G	F-G	F-G	F-G	P	F	
tropical spiderwort	N	N	N	F	F	P-F	N	P	E	P	
volunteer peanuts	N	N	N	N	P-F	P	P	P	P	P	P
wild poinsettia	N	N	N	F	N	N	G-E	G	P	G	

[1]Assumes irrigation or rainfall occurs within 48 hrs.
[2]Fair on pitted morningglory.
[3]Staple does not control tall morningglory or ALS-resistant Palmer amaranth.

Key**:** E = 90% or better control; G = 80% to 90% control; F = 60% to 80% control; P = 30% to 60% control; N = < 30% control.
Note: Ratings based upon average to good soil and weather conditions for herbicide performance and upon proper application rate, technique, and timing.

Weed Species	POST OVER-THE-TOP					
	Assure	Fusilade	Poast	Select/Select Max	MSMA[1]	Cotoran
Perennials						
bermudagrass	G	G	F	G	N	N
johnsongrass (rhizome)	E	G-E	G	G-E	P	N
purple nutsedge	N	N	N	N	N-P	N
yellow nutsedge	N	N	N	N	P	N
Annual Grasses						
broadleaf signalgrass	G	G-E	E	E	P	P
crabgrass	G	G	G-E	G-E	P	P-F
crowfootgrass	G	F	F-G	G	P	P-F
fall panicum	G-E	G-E	E	E	P	P-F
foxtails	E	E	E	E		
goosegrass	G	G	G-E	G-E	P	P-F
johnsongrass (seedling)	E	G-E	G-E	E	P	P
sandbur		G	G	G	P	P
Texas panicum	G	G	E	E	N-P	N
Annual Broadleaves						
bristly starbur	N	F-G	N	N	P	G
burgherkin	N	N	N	N	P-F	F-G
citronmelon	N	N	N	N	P-F	G
cocklebur	N	N	N	N	E	F-G
coffee senna	N	N	N	N	P-F	F-G
cowpea	N	N	N	N	F	F-G
crotalaria	N	N	N	N	F	G
eclipta	N	N	N	N		
Florida beggarweed	N	N	N	N	E	G
Florida pusley	N	N	N	N	N-P	P-F
hemp sesbania	N	N	N	N		
jimsonweed	N	N	N	N	P	G
lambsquarters	N	N	N	N	P	G
morninglories	N	N	N	N	P-F	G
Palmer amaranth	N	N	N	N	P	P-F
pigweeds: smooth and redroot	N	N	N	N	P	F
prickly sida	N	N	N	N	P	F-G
purslane	N	N	N	N	P-F	F-G
ragweed	N	N	N	N	P-F	G
redweed	N	N	N	N	N	F-G
sicklepod	N	N	N	N	P-F	F-G
smartweed: ladysthumb	N	N	N	N	N-P	F-G
Pennsylvania	N	N	N	N	N-P	F-G
spider flower	N	N	N	N		F
spurge	N	N	N	N	N	P-F
tropic croton	N	N	N	N	F	F-G
tropical spiderwort	N	N	N	N	P	P
volunteer peanuts	N	N	N	N	P	F
wild poinsettia	N	N	N	N	P	F

[1]MSMA is no longer labeled for this use but ratings are provided for existing stocks with previous labeling.

Key**:** E = 90% or better control; G = 80% to 90% control; F = 60% to 80% control; P = 30% to 60% control; N = < 30% control.

Note: Ratings based upon average to good soil and weather conditions for herbicide performance and upon proper application rate, technique, and timing.

Weed Species	POST OVER-THE-TOP						
	Staple	Envoke	Envoke + Staple	glyphosate[2]	glyphosate[2] + Staple	glyphosate[2] + Envoke	Ignite[3]
Perennials							
bermudagrass	N	N	N	F	F	F	N
johnsongrass (rhizome)	N-P	P	N-P	G-E	G-E	G-E	F
purple nutsedge	P-F	F-G	F-G	F-G	F-G	E	F
yellow nutsedge	P-F	G	G	F	F-G	E	F
Annual Grasses							
broadleaf signalgrass	N	N	N	E	E	E	G
crabgrass	N	P	P	E	E	E	G
crowfootgrass	N	N	N	E	E	E	G
fall panicum	N	N-P	P	E	E	E	G
foxtails	N-P	N-P	N-P	E	E	E	G
goosegrass	N-P	N-P	N-P	E	E	E	P
johnsongrass (seedling)	P	F	P-F	E	E	E	G
sandbur	P			E	E	E	G
Texas panicum	N	N-P	P	E	E	E	G
Annual Broadleaves							
bristly starbur	G	G-E	G-E	E	E	E	G
burgherkin	G			G-E	G-E	G-E	
citronmelon	G-E	G-E	G-E	G-E	E	E	G
cocklebur	G	G-E	E	E	E	E	E
coffee senna	G			E	E	E	G
cowpea	G	G	G-E	E	E	E	G
crotalaria				G	G	G	
eclipta	G	P-F		E	E	E	G
Florida beggarweed	G	G-E	G-E	E	E	E	G
Florida pusley	N-P	P	P	P-G	P-G	P-G	F
hemp sesbania	G-E			P-F	G-E		
jimsonweed	E	N		E	E	E	E
lambsquarters	N	G		G	G	E	E
Ipomoea morningglory	G[1]	G	G-E	F-G	G-E	E	E
Smallflower morningglory	E	N	E	G	E	G	E
Palmer amaranth	F	P-F	F	E	E	E	F-G
Palmer amaranth (glyphosate-resistant)	F	P-F	F	N	F	P-F	F-G
Palmer amaranth (glyphosate-and ALS resistant)	N	N	N	N	N	N	F-G
pigweed: smooth and redroot	G	F-G	G	E	E	E	G
prickly sida	F	N	F	F-G	G	G	F
purslane	F			F-G	G	G	F-G
ragweed, common	P	G		E	E	E	E
redweed	G			E	E		
sicklepod	P-F	E	E	E	E	E	E
smartweed: ladysthumb	G	G		G	E	E	E
Pennsylvania	G	G		G	E	E	G
spider flower							
spurge	F-G			G	G	G	F-G
tropic croton	P	P-F	P-F	E	E	E	G
tropical spiderwort	F	P-F	F	P-G	G	P-G	P-F
volunteer peanuts	P	P-F		F-G	F-G	F-G	G-E
wild poinsettia	F	G		G-E	G-E	E	P-F

[1]Staple does not control tall morningglory.
[2]Glyphosate should be applied only to glyphosate-resistant cultivars. All formulations of glyphosate are not labeled for this use.
[3]Ignite should be applied to cotton tolerant of Ignite such as LibertyLink.

Key: E = 90% or better control; G = 80% to 90% control; F = 60% to 80% control; P = 30% to 60% control; N = < 30% control.
Note: Ratings based upon average to good soil and weather conditions for herbicide performance and upon proper application rate, technique, and timing.

Weed Species	POSTEMERGENCE-DIRECTED							
	MSMA	Cotoran + MSMA	Caparol + MSMA	Direx, others + MSMA	Direx + Linex + MSMA	Cobra + MSMA	Valor + MSMA	Suprend + MSMA
Perennials bermudagrass	N	N	N	N	N	N	N	N
johnsongrass (rhizome)	P	P	P	P	P	P	P	P
purple nutsedge	F	F	F	F	F	F	F-G	E
yellow nutsedge	F-G	F-G	F-G	G	G	F-G	G	E
Annual Grasses broadleaf signalgrass	F	F	F-G	G	G	P-F	F	F-G
crabgrass	F	F	F-G	G	G	P-F	F	F-G
crowfootgrass	F	F	F-G	F-G	F-G	P-F	F	F-G
fall panicum	F	F	F-G	F-G	F-G	P-F	F	F-G
foxtails	F	F	F-G	F-G	F-G	P-F	F	F-G
goosegrass	F	F	F-G	F-G	F-G	P-F	F	F-G
johnsongrass (seedling)	F	F	F-G	F-G	F-G	P-F	F	F-G
sandbur	F	F	F-G	F-G	F-G	P-F	F	F-G
Texas panicum	P	P	F	F	F	P	P-F	F
Annual Broadleaves bristly starbur	P-F	G	G	G	G	G	G	G-E
burgherkin	F	F-G	G	G	G	G		
citronmelon	F	G	F-G	G	G	G		
cocklebur	E	E	E	E	E	E	E	E
coffee senna	F	G	G	G	G	F	G	
cowpea	F-G	G	G	G	G	F-G	G	
crotalaria	G	G	G	G	G	G		
eclipta		G	G	E	E	E	E	E
Florida beggarweed	E	E	E	E	E	E	E	E
Florida pusley	P	F	F	F	F	F	F-G	F
hemp sesbania	N	P-F	P-F	P-F		F		
jimsonweed	F	G-E	G	G	G	G-E	E	G
lambsquarters	P-F	G	G	G	G	F	F-G	G-E
morninglories	F	G	G-E	G-E	G-E	E	E	E
Palmer amaranth	P	F	F	G-E	G-E	F	F-G	G-E
pigweeds: redroot or smooth	P-F	G	G	G-E	G-E	G	G-E	G-E
prickly sida	P	F-G	G-E	G-E	G-E	G-E	G-E	G-E
purslane	P-F	F-G	F-G	G	G	G	G	
ragweed, common	F	G-E	E	E	E	E	G-E	E
redweed	N	F-G	G	G-E		F		
sicklepod	F	G	G-E	G-E	G-E	P-F	G-E	E
smartweed: ladysthumb & Penn	P	G	F	F	F	F	G	
spider flower	G-E (in bloom)	G-E (in bloom)	G-E (in bloom)	G-E (in bloom)	G-E (in bloom)	G-E (in bloom)		
spurge	N	P-F	G	G	G	G	G	
tropic croton	F	G	G	G	G	E	E	G-E
tropical spiderwort	F	G	F-G	G	G	F-G	G-E	F-G
volunteer peanuts	P-F	F-G	F-G	G	G	P-F	F-G	G
wild poinsettia	P-F	F	P-F	P-F		G	G	

Key**:** E = 90% or better control; G = 80% to 90% control; F = 60% to 80% control; P = 30% to 60% control; N = < 30% control.
Note: Ratings based upon average to good soil and weather conditions for herbicide performance and upon proper application rate, technique, and timing.

Weed Species	POSTEMERGENCE-DIRECTED (continued)							HOOD
	glyphosate[1]	glyphosate[1] + Direx	glyphosate[1] + Aim	glyphosate[1] + Envoke	glyphosate[1] + Staple	glyphosate[1] + Valor	Ignite[2]	Gramoxone[3]
Perennials bermudagrass	F	F	F	F	F	F	N	P
johnsongrass (rhizome)	G-E	G	G-E	E	G-E	G-E	F	P
purple nutsedge	F-G	G	F-G	E	F-G	G	P	P-F
yellow nutsedge	F	F-G	F	E	F-G	G	P	P-F
Annual Grasses broadleaf signalgrass	E	G-E	E	E	E	E	G	G-E
crabgrass	E	G-E	E	E	E	E	F-G	G
crowfootgrass	E	G-E	E	E	E	E	G	G
fall panicum	E	G-E	E	E	E	E	G	G
foxtails	E	G-E	E	E	E	E	G	G
goosegrass	E	G-E	E	E	E	E	P	G
johnsongrass (seedling)	E	G-E	E	E	E	E	G	G
sandbur	E	G-E	E	E	E	E	G	G
Texas panicum	E	G-E	E	E	E	E	G	G
Annual Broadleaves bristly starbur	G-E	G-E	G-E	G-E	G-E	E	G	E
burgherkin	G	G	G		G			F
citronmelon	G-E	G-E	G-E	E	E	E	G	G
cocklebur	E	E	E	E	E	E	E	G
coffee senna	E	E	E	E	E	E	G	F
cowpea	G-E	G-E	G-E	G-E	G-E	E	G	G
crotalaria	G	G	G		G			
eclipta	E	E	E	E	E	E	G	F
FL beggarweed	E	E	E	E	E	E	G	E
Florida pusley	P-G	G	G	P-G	P-G	G-E	F	P-F
hemp sesbania	P-F		G-E		G-E			F
jimsonweed	E	E	E	E	E	E	E	G
lambsquarters	G	G-E	G-E	G-E	G-E	G-E	E	F
morning glory - *Ipomoea*	F-G	G-E	E	E	G-E	E	E	F-G
morningglory - smallflower	G	E	E	G	E	E	E	P-F
Palmer amaranth	E	E	E	E	E	E	F-G	G-E[3]
Palmer amaranth (glyphosate-resistant)	N	F-G	P-F	P	F	P-F	F-G	G-E[3]
Palmer amaranth (glyphosate & ALS resis.)	N	F-G	P-F	N	N	P-F	F-G	G-E[3]
pigweed: redroot or smooth	E	E	E	E	E	E	G	G-E[3]
prickly sida	F-G	G	F-G	F-G	G	G-E	F-G	P-F
purslane	F-G	G-E	G			G-E	F-G	G
ragweed, common	E	E	E	E	E	E	E	F
redweed	G-E	G-E	G-E		G-E			F-G
sicklepod	E	E	E	E	E	E	E	G-E
smartweed:	G	G	G-E	E	E	G	G-E	G
spider flower			G			G		
spurge	G	G-E	G-E	G	G	G	F-G	
tropic croton	E	E	E	E	E	E	G	F
tropical spiderwort	P-F	F-G	G-E	P-F	F-G	G-E	P-F	G-E
volunteer peanuts	F	G	F-G	F-G	F	F-G	G-E	P
wild poinsettia	G	G	G-E	E	G	G-E	P-F	G

[1]Glyphosate should be applied only to glyphosate-resistant cotton.
[2]Ignite should be applied only to cultivars tolerant of Ignite. Must apply to grasses two inch or smaller.
[3]The addition of diuron with Gramoxone is needed for this level of control.
Key**:** E = 90% or better control; G = 80% to 90% control; F = 60% to 80% control; P = 30% to 60% control; N = < 30% control.
Note: Ratings based upon average to good soil and weather conditions for herbicide performance and upon proper application rate, technique, and timing

Appendix VII. Herbicide Ingredients and Modes of Action

Brand Name(s)	Active Ingredient(s)	Mode(s) of Action[1]
AAtrex	atrazine	5
Accent, Accent Q	nicosulfuron	2
Acumen	pendimethalin	3
Adapt	nicosulfuron	2
Aim	carfentrazone	14
Alachlor	alachlor	15
Alanap	naptalam	19
Arrow	clethodim	1
Atrazine	atrazine	5
Assure II	quizalofop	1
Audit	thifensulfuron + tribenuron	2 + 2
Authority Assist	sulfentrazone + imazethapyr	14 + 2
Authority First	sulfentrazone + cloransulam	14 + 2
Authority MTZ	sulfentrazone + metribuzin	14 + 5
Authority XL	sulfentrazone + chlorimuron	14 + 2
Axial XL	pinoxaden	1
Axiom	flufenacet + metribuzin	15 + 5
Banvel	dicamba	4
Basagran	bentazon	6
Basis	rimsulfuron + thifensulfuron	2 + 2
Beyond	imazamox	2
Bicep II Magnum	s-metolachlor + atrazine	15 + 2
Blazer	acifluorfen	14
Boundary	s-metolachlor + metribuzin	15 + 5
Brawl, Brawl II	s-metolachlor	15
Brawl II ATZ	s-metolachlor + atrazine	15 + 5
Breakfree ATZ	s-metolachlor + atrazine	15 + 5
Break-up	pronamide	3
Broclean	bromoxymil	6

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Brand Name(s)	Active Ingredient(s)	Mode(s) of Action[1]
Buctril	bromoxynil	6
Bullet	alachlor + atrazine	15 + 5
Butoxone	2,4-DB	4
Butyrac	2,4-DB	4
Cadence	acetochlor	15
Cadence ATZ	acetolchlor + atrazine	15 + 5
Cadre	imazapic	2
Callisto	mesotrione	27
Camix	mesotrione + s-metolachlor	27 + 15
Canopy	metribuzin + chlorimuron	5 + 2
Canopy EX	chlorimuron + tribenuron	2 + 2
Canopy XL	sulfentrazone + chlorimuron	14 + 2
Caparol	prometryn	5
Capreno	tembotrione + thiencarbazone	27 + 2
Celebrity, Celebrity Plus	nicosulfuron + dicamba	2 + 4
Charger Basic	s-metolachlor	15
Chateau	flumioxazin	14
Cinch	s-metolachlor	15
Cinch ATZ	s-metolachlor + atrazine	15 + 5
Clarity	dicamba	4
Classic	chlorimuron	2
Clethodim	clethodim	1
Clopyr AG	clopyralid	4
Cobra	lactofen	14
Command	clomazone	13
Confidence	acetochlor	15
Confidence Xtra	acetochlor + atrazine	15 + 5
Cotoran	fluometuron	7
Cotton-Pro	prometryn	5
Crossing	sulfentrazone	14

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Brand Name(s)	Active Ingredient(s)	Mode(s) of Action[1]
Curbit	ethalfluralin	3
Dacthal	DCPA	3
Dawn	fomesafen	14
Define	flufenacet	15
Degree	acetochlor	15
Degree Xtra	acetochlor + atrazine	15 + 5
Detonate	dicamba	4
Devrinol	napropamide	15
Diablo	dicamba	4
Dicamba	dicamba	4
Dimetric	metribuzin	5
Direx	diuron	7
Distinct	dicamba	4
Diuron	diuron	7
Double Team	acetochlor + atrazine	15 + 5
DSMA, numerous brands	DSMA	17
Dual, Dual II, Dual II Magnum	metolachlor or s-metolachlor	15
Edition Broadspec	thifensulfuron + tribenuron	2 + 2
Edition Tankmix	thifensulfuron + tribenuron	2 + 2
Envive	flumioxazin + cloransulam + thifensulfuron	14 + 2 + 2
Envoke	trifloxysulfuron	2
Eptam	EPTC	8
Equip	foramsulfuron + iodosulfuron	2 + 2
Eradicane	EPTC	8
Establish	dimethenamid	15
Establish ATZ	dimethenamid + atrazine	15 + 5
ET	pyraflufen ethyl	14
Evik	ametryne	5

Appendix VII. Herbicide Ingredients and Modes of Action

Brand Name(s)	Active Ingredient(s)	Mode(s) of Action[1]
Expert	glyphosate + s-metolachlor + atrazine	9 + 15 + 5
Express	tribenuron	2
Extreme	glyphosate + imazethapyr	9 + 2
Finesse	chlorsulfuron + metsulfuron	2 + 2
Finesse Grass & Broadleaf	chlorsulfuron + flucarbazone	2 + 2
Firestorm	paraquat	22
Firstrate	cloransulam	2
Firstshot	thifensulfuron + tribenuron	2 + 2
Flexstar	fomesafen	14
Flexstar GT	fomesafen + glyphosate	14 + 9
FulTime	acetochlor + atrazine	15 + 5
Fusilade DX	fluazifop	1
Fusion	fluazifop + fenoxaprop	1 + 1
Galigan	oxyfluorfen	14
Gangster	flumioxazin + cloransulam	14 + 2
Glyphosate (numerous brands)	glyphosate	9
Goal, Goal Tender	oxyfluorfen	14
Gramoxone Inteon or Max	paraquat	22
Guardsman Max	dimethenamid + atrazine	15 + 5
Halex GT	s-metolachlor + glyphosate + mesotrione	15 + 9 + 27
Harmony Extra	thifensulfuron + tribenuron	2 + 2
Harmony GT, Harmony SG	thifensulfuron	2
Harness	acetochlor	15
Harness Xtra	acetochlor + atrazine	15 + 5
Hoelon	diclofop	1
Ignite, Ignite 280	glufosinate	10
Impose	imazapic	2
Intensity	clethodim	1

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Brand Name(s)	Active Ingredient(s)	Mode(s) of Action[1]
Intrro	alachlor	15
Ironclad	nicosulfuron + rimsulfuron	2 + 2
Karmex	diuron	7
Kerb	pronamide	3
Keystone	acetochlor + atrazine	15 + 5
Lariat	alachlor + atrazine	15 + 5
Laudis	tembotrione	27
Layby Pro	diuron + linuron	7 + 7
Leadoff	imsulfuron + thifensulfuron	2 + 2
Lexar	mesotrione + s-metolachlor + atrazine	27 + 15 + 5
Liberty	glufosinate	10
Liberty ATZ	glufosinate + atrazine	10 + 5
Lightning	imazethapyr + imazapyr	2 + 2
Linex	linuron	7
Linuron	linuron	7
Lorox	linuron	7
Lumax	mesotrione + s-metolachlor + atrazine	27 + 15 + 5
Marksman	dicamba + atrazine	4 + 5
Matrix	rimsulfuron	2
Medal, Medal II	s-metolachlor	15
Medal II AT	s-metolachlor + atrazine	15 + 5
Me-Too-Lachlor	metolachlor	15
Metribuzin	metribuzin	5
Metri DF	metribuzin	5
Micro-Tech	alachlor	15
Moxy	bromoxynil	6
MSMA (numerous brands)	MSMA	17
Optill	imazethapyr + saflufenacil	2 + 14

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Brand Name(s)	Active Ingredient(s)	Mode(s) of Action[1]
Option	foramsulfuron	2
Osprey	mesosulfuron	2
Outlook	dimethenamid	15
OxiFlo	oxyflurofen	14
Overtime	acetochlor	15
Overtime ATZ	acetochlor + atrazine	15 + 5
Parallel, Parallel PCS	metolachlor	15
Parallel Plus	metolachlor + atrazine	15 + 5
Parazone	paraquat	22
Parrlay	metolachlor	15
Peak	prosulfuron	2
Pendant	pendimethalin	3
Pendimax, others	pendimethalin	3
Permit	halosulfuron	2
Poast, Poast Plus	sethoxydim	1
Powerflex	pyroxsulam	2
Prefar	bensulide	8
Prefix	s-metolachlor + fomesafen	15 + 14
Princep, others	simazine	5
Prometryn	prometryn	5
Prowl, Prowl H2O	pendimethalin	3
Pruvin	rimsulfuron	2
Pursuit	imazethapyr	2
Pyrimax	pyrithiobac	2
Python	flumetsulam	2
Quik-Quat	paraquat	22
Rage D-Tech	carfentrazone + 2,4-D	14 + 4
Rapport Broadspec	thifensulfuron + tribenuron	2 + 2

Appendix VII. Herbicide Ingredients and Modes of Action

Brand Name(s)	Active Ingredient(s)	Mode(s) of Action[1]
Rapport Tank Mix	thifensulfuron + tribenuron	2 + 2
Raptor	imazamox	2
Realm Q	rimsulfuron + mesotrione	2 + 27
Reflex	fomesafen	14
Rely	glufosinate	10
Resolve	rimsulfuron	2
Resolve Q	rimsulfuron + thifensulfuron	2 + 2
Resource	flumiclorac-pentyl	14
Rifle	rimsulfuron	2
Roundup, others	glyphosate	9
Rule	rimsulfuron	2
Rhythm	fomesafen	14
Sandea	halosulfuron	2
Scepter	imazaquin	2
Select, Select Max	clethodim	1
Sencor	metribuzin	5
Sequence	glyphosate + s-metolachlor	9 + 15
Shadow	clethodim	1
Sharpen	saflufenacil	14
Simazine	simazine	5
Sim-Trol	simazine	5
Slider	dimethenamid	15
Slider ATZ	dimethenamid + atrazine	15 + 5
Sinbar	terbacil	5
Sonalan	ethalfluralin	3
Sonic	sulfentrazone + cloransulam	14 + 2
Sortie	dimethenamid	15
Sortie ATZ	dimethenamid + atrazine	15 + 5
Spartan	sulfentrazone	14

Appendix VII. Herbicide Ingredients and Modes of Action

Brand Name(s)	Active Ingredient(s)	Mode(s) of Action[1]
Spartan Charge	sulfentrazone + carfentrazone	14 + 14
Squadron	imazaquin + pendimethalin	2 + 3
Stalwart, Stalwart C	metolachlor	15
Stalwart Xtra	metolachlor + atrazine	15 + 5
Staple	pyrithiobac	2
Status	dicamba + diflufenzopyr	4 + 19
Steadfast, Steadfast Q	nicosulfuron + rimsulfuron	2 + 2
Steadfast ATZ	nicosulfuron + rimsulfuron + atrazine	2 + 2 + 5
Stealth	pendimethalin	3
Sterling Blue	dicamba	4
Stinger	clopyralid	4
Storm	acifluorfen + bentazon	14 + 6
Stout	nicosulfuron + thifensulfuron	2 + 2
Strategy	ethalfluralin + clomazone	3 + 13
Strongarm	diclosulam	2
Suprend	prometryn + trifloxysulfuron	5 + 2
Sutan	butylate	8
Surestart	acetoachlor + clopyralid + flumetsulam	15 + 4 + 2
Surpass	acetochlor	15
Synchrony XP	chlorimuron + thifensulfuron	2 + 2
TapOut	clethodim	1
Targa	quizalofop	1
Thunder	imazethapyr	2
TNT Broadleaf	thifensulfuron + tribenuron	2 + 2
Top Gun	fomesafen	14
TopNotch	acetochlor	15
Treflan	trifluralin	3
Triangle	metolachlor + atrazine	15 + 5
Tricor	metribuzin	5

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Brand Name(s)	Active Ingredient(s)	Mode(s) of Action[1]
Trifluralin	trifluralin	3
Trigger	clethodim	1
Trilin	trifluralin	3
Trizmet II	metolachlor + atrazine	15 + 5
Trust	trifluralin	3
Ultra Blazer	acifluorfen	14
Unity	thifensulfuron	2 + 2
Valor SX	flumioxazin	14
Valor XLT	flumioxazin + cloransulam	14 + 2
Verdict	dimethenamid + saflufenacil	15 + 14
Vision	dicamba	4
Volley	acetochlor	15
Volley ATZ	acetochlor + atrazine	15 + 5
Volunteer	clethodim	1
Warrant	acetochlor	15
Weedmaster	2,4-D + dicamba	4 + 4
Yukon	halosulfuron + dicamba	2 + 4
2,4-D (numerous brands)	2,4-D	4
2,4-DB (numerous brands)	2,4-DB	4

[1] The numerical system to describe modes of action is taken from the Weed Science Society of America. Modes of action are as follows:

1 ACCase inhibition
2 ALS inhibition
3 Microtubule assembly inhibition
4 Synthetic auxin
5 Photosystem II, different binding behavior than groups 6 and 7
6 Photosystem II, different binding behavior than groups 5 and 7
7 Photosystem II, different binding behavior than groups 5 and 6
8 Inhibition of lipid synthesis – not ACCase inhibition
9 EPSP synthase inhibition
10 Glutamine synthetase inhibition
12 Inhibition of carotenoid biosynthesis at PDS
13 Inhibition of carotenoid biosynthesis, unknown target
14 PPO inhibition
15 Inhibition of very long-chain fatty acids
17 Unknown mode of action

19	Auxin transport inhibition
22	Photosystem I electron diversion
27	Inhibition of HPPD

PLANT GROWTH REGULATOR USE

The best "growth regulator" for cotton is good, early fruit set and retention, as this will generally deter excess vegetative growth. Therefore, nitrogen levels, soil moisture, insect control, plant population, and crop management influence the cotton plants' ability to balance vegetative and reproductive growth. There are two ways to influence the plants' vegetative/reproductive balance. An indirect influence would be timely applications of boron, which aids flowering and fruit set. As a management tool, growth regulators containing mepiquat are specifically used to reduce vegetative growth. Mepiquat is available in several formulations sold under the trade names of Pix, Pix Plus, Mepex, Mepex Ginout, Topit, Mepichlor, Pentia, and Stance among others. Mepiquat has a number of effects on cotton growth and development. The most consistent effect of mepiquat is the reduction of plant vegetative growth by shortening internode length. It also reduces leaf area in portions of the plant canopy where stem and leaf expansion are taking place. It controls growth in such a way that does not create carbohydrate stress in the plant.

Mepiquat applications are also often associated with a slight increase in early fruit retention and thus, contributes to a trend toward early maturity. Yield responses have been erratic and inconsistent. Slight increases, slight decreases, and no effect are prevalent in the volumes of research dealing with mepiquat. Yield advantages observed with mepiquat-containing products are most often linked to situations in which the product contributes toward reduced boll rot, increased harvest efficiency, improved insecticide/defoliant penetration through the canopy, hastened maturity (in later planted cotton), and retention of earlier-set larger bolls. Most conditions that would likely result in a positive response to mepiquat are not easily predictable, except for some irrigated fields. With the wide range of growth potential among our current modern varieties, it is important to understand the growth potential of any particular variety, and how the environment influences growth of a particular variety, before applying mepiquat. Slower growing earlier maturing varieties may seldom need aggressive PGR management (high rates, prebloom applications, etc) depending upon the prevailing environment.

Mepiquat formulations which include the hormone kinetin (Mepex Ginout), or formulated as a pentaborate salt (Pentia) as opposed to a chloride salt (all others) have resulted in similar yield responses to other mepiquat-containing PGRs in UGA trials. In 2005 and 2006 several small and large plot trials were conducted to evaluate Stance (a premix of mepiquat chloride and cyclanilide). This product is used at lower rates compared to other mepiquat-containing products. Recent experience with this product suggests that Stance, when used at appropriate application rates, has similar effects on plant growth and development, when compared to other mepiquat-containing products. Trials conducted in 2010 suggested that Stance applied at appropriate and recommended rates (usually 2.5 to 3 oz/a depending upon growth stage) may have milder effects on plant growth than the commonly used rates of other mepiquat-containing PGRs. Therefore, Stance may reduce risks of severe stunting due to hot or dry weather following

application, especially for early maturing varieties or varieties that generally portray less aggressive growth.

Currently UGA data indicates that all mepiquat-containing products should be used at the same rates and timings, with the exception of Stance. *The use rate of Stance recommended by Bayer CropScience is 3 oz/A in all situations. This rate may be lowered to 2.5 oz/A if the first application is made prior to, or at the initiation of squaring*. Again, this product has been evaluated in the field by UGA Extension for only a few years.

Even though mepiquat has been available for over 25 years, questions persist about how to use the product. Indications from the literature show that a given rate of mepiquat in a small plant leads to more height/growth reduction than that rate in a large plant. This is related to concentration -- the concentration of a given rate of mepiquat will be greater in a small plant and more dilute in a large plant. If the product is applied when vegetative growth is about complete, little effect on height occurs. After a leaf has fully developed and internodes have elongated, no amount of mepiquat can shrink them. Vigorous plants show less response (reduction in internode length, duration of growth control, etc.) than slower growing plants. In growth chamber studies in Mississippi, mepiquat had less effect on cotton grown at high temperatures (>95^0 F) or on plants under drought stress. Therefore, the activity of mepiquat is greater within plants that are actively growing, with good moisture under warm, moderate temperatures.

Factors that must be considered when determining when and how much mepiquat to use include: (1) stage of plant growth, (2) rate of plant growth, (3) pest control and (4) anticipated plant growth (irrigation, drought, fertility). Because of the many variables, hard and fast rules regarding the rate and timing of mepiquat are not appropriate. Fields vary in growth. Weather varies by year/location, and thus, recommendations must be flexible.

In most irrigated fields, we can comfortably begin low rate applications (4 oz) at least by the second week of squaring and continue on a 14-day interval for three or four applications. Another common approach in irrigated conditions is to apply 8 to 12 oz at first bloom or just prior to bloom, with a subsequent treatment if needed at 8 to 12 oz two or three weeks later. The key to plant management for aggressive varieties may be making applications <u>earlier</u>, when the plant is 12 to 16 inches tall, especially in fields that frequently receive and retain moisture. In dryland situations, applications at, or just prior to, first bloom is usually a time to consider mepiquat at rates near 8 oz, if growth is vigorous. If aggressive growth continues, a follow up treatment may also be needed. These suggestions provide a framework upon which to base timing and rates.

A common error is to delay applications past the point where the product can provide its maximum benefit. If the intent is a single (or at most two) application program, growers should be targeting cotton in the 16 to 24 inch range. Applications that are not made until cotton reaches 30 inches often do not adequately control growth. However, some modern varieties appear to be less aggressive compared to DP 555 BR, in terms of growth rate and potential. Some of these varieties may not require aggressive use of mepiquat, while some may depending upon the prevailing environment and moisture status. Therefore, it is very important for growers to closely monitor plant growth in all fields, and apply mepiquat accordingly, as every situation is different.

Late-season applications of mepiquat has received attention recently. The theory behind these applications is that they will reduced vegetative growth at the time of cut-out thus channeling more energy into the development of late-season bolls. Current UGA research has not shown any

yield advantage, nor a reduction in regrowth potential, resulting from mepiquat applied at this growth stage.

Questions related to ultra-early season applications of mepiquat have also surfaced. These questions have primarily centered around the management of aggressive varieties such as DP 555 BR. The thought is that applying 2 to 6 oz at the 4-leaf stage when the last over-the-top glyphosate application is made will provide additional vegetative growth control. Research to date has not shown any effect whatsoever with these early applications. Now that less aggressive and earlier maturing varieties are being planted, these very early applications may increase the risks associated with stunting.

IRRIGATION

Although cotton is considered to be a relatively drought-tolerant crop, it is an excellent candidate for irrigation. Irrigation is particularly important in areas that frequently have drought in July through August 20 and on sandy soils. Irrigation may increase yields from a range of 0 to more than 800 lb/A, with increases of 200 to 400 lb/A being common. Irrigation is often used as a supplement to rainfall, as total reliance on irrigation would be difficult for some producers. The most critical period is during the bloom and boll maturation periods. At peak bloom, the plant needs about 0.3 inches of water per day.

Many uncertainties exist as to HOW to irrigate. With the exception of 2003, 2005, and 2009, recent years have been characterized by severe, persisting drought, and many irrigated fields have fallen well below expectations in terms of yield and fiber quality. Considerable research is needed to improve our understanding of plant water use, irrigation timing, and irrigation efficiency.

In the past irrigation of cotton prior to blooming was initiated when planted wilted or showed stress by mid-day. Recent research has indicated that once cotton begins to wilt it has already been under physiological stress for some time. Prior to bloom cotton will utilize 0.75 to 1 inch of water per week. Thus, under hot and dry early season conditions to optimize yield potential the crop should be irrigated with this amount prior to the signs of stress. It should also be recognized however, that abundant moisture magnifies vegetative growth problems when excessive nitrogen is available and/or insect control is insufficient.

After first bloom, irrigate as needed to supply the quantities of water listed below. Rain gauges should be used to measure the water received from rain and the amount supplied by irrigation.

Cotton Irrigation Schedule Suggested For High Yields

	In./Week	In./Day
Wk. beginning at 1st bloom	1	0.15
2nd wk. after 1st bloom	1.5	0.22
3rd wk. after 1st bloom	2	0.3
4th wk. after 1st bloom	2	0.3
5th wk. after 1st bloom	1.5	0.22
6th wk. after 1st bloom	1.5	0.22
7th wk. after 1st bloom	1	0.15

Weekly quantities should be increased to compensate for soil type, run-off or evaporation.

Examine the crop during the 7th week and 8th week to determine if irrigation should be continued. Additional irrigation may be needed on deep sands, during hot and dry weather, and in windy conditions. Irrigation intervals can be determined by dividing the quantity/day for a period into ½ to b the available moisture holding capacity of the upper 2 ft of soil in fields. For example, if the available moisture capacity of the soil is 0.7 inches/ft and the quantity/day is 0.3 inches, the interval between irrigations or following rain that brings soil moisture to field capacity would be 0.66 (available moisture) x 2 ft x 0.7 inches/ft divided by 0.3 inches/day = 3.08, which is rounded to 3 days. Intervals for most of the season will be 3 to 4 days for coarse textured sand, 4 to 6 days for more productive loamy sand and sandy loam, and 5 to 8 days for fine textured sandy loam or clay soils. A 4 to 6 day interval will fit a majority of the situations.

Growers with intensely managed production programs that are already harvesting 2-bale yields and are striving for 3-bale-plus yields on part of their crop may want to increase the amount of water supplied by irrigation if water availability appears to be a limiting factor. Irrigation termination is a difficult decision. A final watering is often made when the crop begins to open. Commonly, NO additional irrigation is applied once the time the crop is 10 percent open to minimize problems with boll rot, hard lock, and light spot. Common sense factors include prevailing weather patterns and predictions, available soil moisture, and time of year.

DEFOLIATION, HARVESTING, AND STORAGE

Cotton defoliates much easier when a good boll load has been obtained and available soil nitrogen is already used up by the crop. A cutout, a mature crop is considerably easier to defoliate than one that maintains vigorous vegetative growth and fruiting into harvest time.

Harvest aid products perform several functions, the most important being defoliation, regrowth suppression, and boll opening. Removal of juvenile growth (late season immature foliage) and desiccation of weeds are functions also needed in certain situations. Of the many harvest aid chemicals, none will perform all these functions under all conditions. As a result, combinations of products are generally recommended and are frequently used, with adjustments in rates and product selection based on crop condition, temperature, calendar date, and equipment availability.

Refer to Appendix VIII: Cotton Defoliation / Harvest Aid Options (as seen in the 2012 Pest Management Handbook) below for information about rates and combinations of harvest aids.

Timing of Defoliation

Timing of Defoliation is critical to insure optimum yield and fiber quality. Several factors can be used to determine the proper time for harvest aid application. The first is the traditional method of counting open and unopen bolls. Defoliation should proceed when least 60 to 75 percent of bolls are open. This method focuses primarily on the "open" portion of the bolls while ignoring the "unopen" portion, which is also important. A second indicator involves slicing bolls with a sharp knife. Bolls are considered mature--and ready for harvest aid applications--when bolls cannot be sliced without "stringing" the lint. In addition, bolls are mature when the seed embryo contains only tiny folded leaves (no "jelly" within the developing seed) and the seedcoat begins to turn yellow or tan. A final method utilized to determine crop maturity is counting nodes above cracked boll (NACB). NACB is determined by counting the number of nodes separating the uppermost first position cracked boll and the uppermost first position boll that is expected to be harvested. Once the NACB has reached 4 it is generally safe to apply harvest aids. In some cases, when plant populations are low, a NACB of 3 maybe more appropriate. Growers should understand that each method of determining defoliation timing considers different plant characteristics, therefore the use of a combination of these methods would more accurately depict maturity of plants and provide a better indication for optimal defoliation timing.

Ethephon-Boll Ripening Agent

Ethephon is a plant regulator marketed as Prep, Ethephon 6, Pluck, Super Boll and several others. It speeds boll opening, and can also accelerate or enhance defoliation under adverse conditions. In many trials ethephon has approximately doubled the percent of bolls that opened during the 7 to 14 day period following application. Rates of defoliant can generally be reduced when ethephon is used (See Appendix VIII). It can occasionally be used in a salvage situation on late cotton to prevent bolls from freezing. It can also facilitate once-over harvest with careful scheduling. The normal harvest interval after ethephon application is 10 to 14 days in early to midseason and extends to 17 to 21 days as weather gets cooler.

CottonQuik and Finish, have been available since 1997. In 2006, CottonQuik was replaced with FirstPick. While these products provide significant defoliation, their primary use is the acceleration of boll opening. Both products provide slightly faster boll opening than equivalent rates of ethephon. This faster boll opening is generally observed up to 10 to 12 days after defoliation. After 14 days, there is generally no difference in boll opening between these products and generic ethephon. Routinely, these products should be mixed with other defoliants such as DEF/Folex, Dropp/Free Fall, Ginstar, Aim or ET to achieve better overall performance. Selection of the tank-mix partner should be based on the needs beyond boll opening. For example, in regrowth situations, Dropp/FreeFall, or Ginstar is an appropriate choice; if only defoliation is needed, options include DEF/Folex (at reduced rates), or several other herbicidal defoliants.

A detailed discussion of crop maturity determinations, timing of application, and harvest-aid chemicals can found in Extension Bulletin 1239 "Cotton Defoliation, Harvest Aids, and Crop Maturity". This publication is available on-line via the UGA cotton web page at www.ugacotton.com.

COTTON DEFOLIATION / HARVEST AID OPTIONS

Jared Whitaker, Extension Agronomist & Guy Collins, Extension Agronomist

The following are basic guidelines for harvest aid application. Rates indicated are amount per acre. Specific rates should be adjusted according to temperature, humidity, day-length, plant leaf condition and maturity, expected weather, and desired effects such as defoliation, regrowth control, boll opening and/or weed control. Defoliants should be applied in a minimum spray volume of 5 gallons per acre by air and 10 to 20 gallons per acre by ground. Reduced performance issues are often related to low spray volume and poor canopy penetration. Fields should be fit into one of the following categories based on temperature and harvest aid function. Preparing cotton for harvest is often difficult and is influenced by many factors, therefore the guidelines below should be considered and basic recommendations. Always observe label restrictions before using cotton harvest aids.

EARLY-SEASON (highs 90°F plus, lows 70°F plus)			
HARVEST-AID FUNCTION	PRODUCT COMMON NAME (BRAND NAME)	BROADCAST RATE/ACRE	REMARKS AND PRECAUTIONS **The rates below are given in the broadcast amount per acre unless otherwise noted.**
Defoliation Only (combinations provide more consistent defoliation than a single product)	tribufos (Def/Folex)	1.5 pt.	Reduce rate to 1.25 pt. if above 94°F.
	carfentrazone (Aim EC)	0.75 to 1 oz.	Add in 0.25% non-ionic surfactant. The potential for leaf sticking is greater during periods of high temperatures.
	pyraflufen ethyl (ET)	1.5 oz.	Add crop oil at 0.5% v/v. The potential for leaf sticking is greater during periods of high temperatures.
	flumiclorac (Resource)	4 to 6 oz.	Add crop oil at 1 to 2 pt. Limited data, use precaution. The potential for leaf sticking is greater during periods of high temperatures.
	fluthiacet-methyl (Blizzard)	0.5 to 0.6 oz.	Add crop oil at 1 pt. Limited data, use precaution.
	sodium chlorate	3 lb. a.i.	Apply to mature foliage only. Do not mix with products containing tribufos or ethephon.
Regrowth Control and Defoliation	thidiazuron (numerous brands)	3.2 oz.	For maximum regrowth control. Thidiazuron is sensitive to wash-off when rain occurs within 6 to 12 hours after application. Addition of tribufos (4 to 8 oz.) or ammonium sulfate (2 lb./A) enhances rainfastness.
	thidiazuron (numerous brands) + tribufos (Def/Folex)	1.6 to 2.5 oz. + 4 to 16 oz.	For minimum regrowth control apply thidiazuron at 1.6 oz. plus tribufos at 8 to 12 oz For good regrowth control apply thidiazuron at 2.5 oz. plus tribufos at 8 to 12 oz. For superior regrowth control apply thidiazuron at 3.2 oz. plus tribufos at 6 to 8 oz. These combinations may cause "leaf sticking" when temperatures exceed 94°F, when combined with spray adjuvants, or when calibration errors occur. Consider reducing higher rates of tribufos by 10 – 20% when temperatures exceed 94°F. Regrowth control or suppression is minimal when thidiazuron is applied at rates below 1.6 oz. Higher rates (2.5 to 3.2 oz.) or sequential applications increase time of effectiveness.
	thidiazuron (numerous brands) + ONE OF THE FOLLOWING: carfentrazone (Aim EC) pyraflufen ethyl (ET) flumiclorac (Resource) fluthiacet-methyl (Blizzard)	1.6 to 2.5 oz. + 0.75 oz 1.5 oz. 4 to 6 oz. 0.5 to 0.6 oz.	 Add 0.25 % v/v non-ionic surfactant. Add 0.5% v/v crop oil. Add crop oil at 1 pt. Limited data, use precaution.. Add crop oil at 1 pt. Limited data, use precaution. The potential for leaf sticking is greater during periods of high temperatures.
	thidiazuron + diuron (numerous brands)	6.4 to 8 oz.	Limited data are available with these products. Regrowth control is minimal when some brand products are applied at rates below 6.4 oz. Likelihood of leaf sticking may occur when temperatures exceed 94°F or when high rates are used.
	glyphosate (numerous brands) + tribufos (Def/Folex)	1.2 to 2 pt. + 8 to 16 oz.	Glyphosate WILL NOT provide regrowth suppression when applied to RF cotton. See specific labels for product rates.

COTTON DEFOLIATION / HARVEST AID OPTIONS (continued)

EARLY-SEASON (highs 90°F plus, lows 70°F plus)			
HARVEST-AID FUNCTION	PRODUCT COMMON NAME (BRAND NAME)	BROADCAST RATE/ACRE	REMARKS AND PRECAUTIONS **The rates below are given in the broadcast amount per acre unless otherwise noted.**
Boll Opening and Defoliation	ethephon (numerous brands)	2.0 to 2.67 pt.	
	ethephon (numerous brands)	1.33 to 1.5 pt.	
	+	+	
	ONE OF THE FOLLOWING:		
	tribufos (Def/Folex)	1 to 1.25 pt.	
	thidiazuron (numerous brands)	1.6 oz.	
	thidiazuron + diuron (numerous brands)	4 to 6 oz.	Likelihood of "leaf sticking" is increased when applied at or above 5 oz in combinations of defoliants. Rate of 4 oz. suggested during periods of high temperatures.
	carfentrazone (Aim EC)	0.75 oz.	Add 0.25 % v/v non-ionic surfactant.
	pyraflufen ethyl (ET)	1.5 oz.	Add 0.5% v/v crop oil.
	flumiclorac (Resource)	4 to 6 oz.	Add 1 to 2 pt. crop oil. Limited data, use precaution.
	fluthiacet-methyl (Blizzard)	0.5 to 0.6 oz.	Add 1 pt. crop oil. Limited data, use precaution.
	ethephon + urea sulfate (FirstPick)	1.75 to 2 qt.	Likelihood of leaf sticking is increased during periods of high temperatures.
	+	+	
	ONE OF THE FOLLOWING:		
	tribufos (Def/Folex)	4 to 6 oz.	
	thidiazuron (numerous brands)	1.6 oz.	
	thidiazuron + diuron (Ginstar/Adios)	4 to 6 oz.	Likelihood of "leaf sticking" increases when applied at or above 5 oz. in combinations of defoliants. Rate of 4 oz. recommended during early season.
	carfentrazone (Aim EC)	0.75 oz.	
	pyraflufen ethyl (ET)	1.5 oz.	
	flumiclorac (Resource)	4 to 6 oz.	Add 1 to 2 pt. crop oil. Limited data, use precaution.
	fluthiacet-methyl (Blizzard)	0.5 to 0.6 oz.	Add 1 pt. crop oil. Limited data, use precaution.
	ethephon + cyclanilide (Finish 6 Pro)	1.33 to 1.5 pt.	
	+	+	
	ONE OF THE FOLLOWING:		
	tribufos (Def/Folex)	4 to 6 oz.	
	thidiazuron (numerous brands)	1.6 oz.	
	thidiazuron + diuron (Ginstar/Adios)	4 to 6 oz.	Likelihood of "leaf sticking" increases when applied at or above 5 oz. in combinations of defoliants. Rate of 4 oz. recommended during early season.
	carfentrazone (Aim EC)	0.75 oz.	Add 0.25 % v/v non-ionic surfactant.
	pyraflufen ethyl (ET)	1.5 oz.	Add 0.5% v/v crop oil.
	flumiclorac (Resource)	4 to 6 oz.	Add 1 to 2 pt. crop oil. Limited data, use precaution.
	fluthiacet-methyl (Blizzard)	0.5 to 0.6 oz.	Add 1 pt. crop oil. Limited data, use precaution.
Boll Opening, Regrowth Control, and Defoliation	ethephon (numerous brands)	1.33 to 1.5 pt.	
	+	+	
	ONE OF THE FOLLOWING:		
	thidiazuron (numerous brands)	2.0 to 2.5 oz.	Limited data are available for some products. Regrowth control is minimal when these products are applied at rates below 6.4 oz.
	thidiazuron + diuron (numerous brands)	6.4 oz.	
	ethephon (numerous brands)	1.33 to 1.5 pt.	
	+	+	
	thidiazuron (numerous brands)	2.0 to 2.5 oz.	
	+	+	
	ONE OF THE FOLLOWING:		
	tribufos (Def/Folex)	6 to 12 oz.	
	carfentrazone (Aim EC)	0.75 oz.	Add 0.25 % v/v non-ionic surfactant.
	pyraflufen ethyl (ET)	1.5 oz.	Add 0.5% v/v crop oil.
	flumiclorac (Resource)	4 oz.	Add 1 to 2 pt. crop oil. Limited data, use precaution.
	fluthiacet-methyl (Blizzard)	0.5 oz.	Add 1 pt. crop oil. Limited data, use precaution.
	ethephon + urea sulfate (FirstPick)	1.75 to 2 qt.	Likelihood of "leaf sticking" is increased when temperatures exceed 94°F.
	OR		
	ethephon + cyclanilide (Finish 6 Pro)	1.33 to 1.5 pt.	
	+	+	
	ONE OF THE FOLLOWING:		
	thidiazuron (numerous brands)	1.6 to 2.0 oz.	Limited data are available with some products. Regrowth control is minimal when these products are applied at rates below 6.4 oz.
	thidiazuron + diuron (numerous brands)	6.4 oz.	

MID-SEASON (highs 80 to 89°F plus, lows 60 to 70°F)			
HARVEST-AID FUNCTION	PRODUCT COMMON NAME (BRAND NAME)	BROADCAST RATE/ACRE	REMARKS AND PRECAUTIONS **The rates below are given in the broadcast amount per acre unless otherwise noted.**
Defoliation Only (combinations provide more consistent defoliation than a single product)	tribufos (Def/Folex)	1 to 1.5 pt.	
	carfentrazone (Aim EC)	0.75 to 1 oz.	Add 1% v/v crop for 0.75 oz. rate. Add 0.25% non-ionic surfactant for 1.0 oz. rate
	pyraflufen ethyl (ET)	1.5 oz.	Add 1% v/v crop oil.
	flumiclorac (Resource)	4 to 6 oz.	Add 1 to 2 pt. crop oil. Limited data, use precaution.
	fluthiacet-methyl (Blizzard)	0.5 to 0.6 oz.	Add 1 pt. crop oil. Limited data, use precaution.
	sodium chlorate	4 lb. a.i.	Apply to mature foliage only. Do not mix with products containing tribufos or ethephon.
Regrowth Control and Defoliation	thidiazuron (numerous brands)	3.2 oz.	
	thidiazuron (numerous brands) OR glyphosate + ONE OF THE FOLLOWING: tribufos (Def/Folex) carfentrazone (Aim EC) pyraflufen ethyl (ET) flumiclorac (Resource) fluthiacet-methyl (Blizzard)	2.0 to 2.3 oz. 1.2 to 2 pt. + 1 pt. 0.75 to 1 oz. 1.5 oz. 4 to 6 oz. 0.5 to 0.6 oz.	 Glyphosate WILL NOT provide regrowth suppression when applied to RF cotton. See specific labels for product rates. Add 0.25% v/v non-ionic surfactant to the 0.75 oz. rate or 1% v/v crop oil to the 1.0 oz. rate. Add 1% v/v crop oil. Add 1 to 2 pt. crop oil. Limited data, use precaution. Add 1 pt. crop oil. Limited data, use precaution.
	thidiazuron + diuron (numerous brands)	6.4 to 8 oz.	Limited data are available with these products. Regrowth control is minimal when these products are applied at rates below 6.4 oz.
Boll Opening and Defoliation	ethephon (numerous brands)	2 to 2.67 pt.	
	ethephon (numerous brands) + ONE OF THE FOLLOWING: tribufos (Def/Folex) thidiazuron (numerous brands) thidiazuron + diuron (Ginstar/Adios) carfentrazone (Aim EC) pyraflufen ethyl (ET) flumiclorac (Resource) fluthiacet-methyl (Blizzard)	1.5 to 2.0 pt. + 1 to 1.25 pt. 1.6 oz. 6.4 oz. 0.75 to 1 oz. 1.5 oz. 4 to 6 oz. 0.5 to 0.6	 Limited data are available with some of these products Add 0.25% v/v non-ionic surfactant to the 0.75 oz. rate or 1% v/v crop oil to the 1.0 oz. rate. Add 1% v/v crop oil. Add 1 to 2 pt. crop oil. Limited data, use precaution. Add 1 pt. crop oil. Limited data, use precaution.
	ethephon + urea sulfate (FirstPick) + ONE OF THE FOLLOWING: tribufos (Def/Folex) thidiazuron thidiazuron + diuron (Ginstar/Adios) carfentrazone (Aim EC) pyraflufen ethyl (ET) flumiclorac (Resource) fluthiacet-methyl (Blizzard)	2.0 qt. + 6 to 8 oz. 1.6 oz. 5 oz. 0.75 to 1.0 oz. 1.5 oz. 4 to 6 oz. 0.5 to 0.6 oz.	 Limited data are available with some of these products. Add 1 to 2 pt. crop oil. Limited data, use precaution. Add 1 pt. crop oil. Limited data, use precaution.
	ethephon + cyclanilide (Finish 6 Pro) + ONE OF THE FOLLOWING: tribufos (Def/Folex) thidiazuron (numerous brands) thidiazuron + diuron (numerous brands) carfentrazone (Aim EC) pyraflufen ethyl (ET) flumiclorac (Resource) fluthiacet-methyl (Blizzard)	1.33 to 1.5 pt. + 6 to 8 oz. 1.6 oz. 5 oz. 0.75 to 1.0 oz. 1.5 oz. 4 to 6 oz. 0.5 to 0.6 oz.	 Limited data are available with some of these products. Add 0.25% v/v non-ionic surfactant to the 0.75 oz. rate or 1% v/v crop oil to the 1.0 oz. rate. Add 1% v/v crop oil. Add 1 to 2 pt. crop oil. Limited data, use precaution. Add 1 pt. crop oil. Limited data, use precaution.

MID-SEASON (highs 80 to 89°F plus, lows 60 to 70°F) (continued)			
HARVEST-AID FUNCTION	PRODUCT COMMON NAME (BRAND NAME)	BROADCAST RATE/ACRE	REMARKS AND PRECAUTIONS **The rates below are given in the broadcast amount per acre unless otherwise noted.**
Boll Opening, Regrowth Control, and Defoliation	ethephon (numerous brands) + ONE OF THE FOLLOWING: thidiazuron (numerous brands) thidiazuron + diuron (numerous brands)	1.5 to 2 pt. + 2.0 to 2.6 oz. 6.4 to 8 oz.	 Limited data are available with some of these products.
	ethephon (numerous brands) + thidiazuron (numerous brands) + ONE OF THE FOLLOWING: tribufos (Def/Folex) carfentrazone (Aim EC) pyraflufen ethyl (ET) flumiclorac (Resource) fluthiacet-methyl (Blizzard)	1.5 to 2 pt. + 2.0 to 2.3 oz. + 8 to 12 oz. 0.75 to 1.0 oz. 1.5 oz. 4 oz. 0.5 oz.	 Add 0.25% v/v non-ionic surfactant to the 0.75 oz. rate or 1% v/v crop oil to the 1.0 oz. rate. Add 1% v/v crop oil. Add 1 to 2 pt. crop oil. Limited data, use precaution. Add 1 pt. crop oil. Limited data, use precaution.
	ethephon + urea sulfate (FirstPick) OR ethephon + cyclanilide (Finish 6 Pro) + ONE OF THE FOLLOWING: thidiazuron (numerous brands) thidiazuron + diuron (numerous brands)	2 qt. 1.5 to 2 pt. + 2.0 to 2.3 oz. 6.4 to 8 oz.	 Limited data are available with some of these products.
LATE-SEASON (highs below 80°F, lows below 60°F) **In these conditions, proper defoliation may require a preconditioning treatment (see preconditioning section).**			
Defoliation Only (combinations provide more consistent defoliation than a single product)	tribufos (Def/Folex) + paraquat (numerous brands)	1.5 pt. + 1 to 6 oz.	 May cause crop desiccation and damage to unopened bolls.
	thidiazuron + diuron (numerous brands)	8 to 10 oz.	Limited data are available with some of these products.
	carfentrazone (Aim EC)	1.0 oz.	
	pyraflufen ethyl (ET)	1.5 oz.	
	flumiclorac (Resource)	4 to 6 oz.	Add 1 to 2 pt. crop oil. Limited data, use precaution.
	fluthiacet-methyl (Blizzard)	0.5 to 0.6 oz.	Add 1 pt. crop oil. Limited data, use precaution.
	sodium chlorate	4 lb. a.i.	
Boll Opening and Defoliation	ethephon (numerous brands)	2 to 2.67 pt.	
	ethephon (numerous brands) + ONE OF THE FOLLOWING: tribufos (Def/Folex) thidiazuron + diuron (numerous brands) carfentrazone (Aim EC) pyraflufen ethyl (ET) flumiclorac (Resource) fluthiacet-methyl (Blizzard)	2 to 2.67 pt. + 1 to 1.25 pt. 6 oz. 1 oz. 1.5 oz. 4 to 6 oz. 0.5 to 0.6	 Limited data are available with some of these products. Add 1% v/v crop oil. Add 1% v/v crop oil. Add 1 to 2 pt. crop oil. Limited data, use precaution. Add 1 pt. crop oil. Limited data, use precaution.
	ethephon + urea sulfate (FirstPick) + ONE OF THE FOLLOWING: tribufos (Def/Folex) thidiazuron + diuron (numerous brands) carfentrazone (Aim EC) pyraflufen ethyl (ET) flumiclorac (Resource) fluthiacet-methyl (Blizzard)	2.0 qt. + 8 to 12 oz. 6 oz. 1.0 oz. 1.5 oz. 4 to 6 oz. 0.5 to 0.6 oz.	 Limited data are available with some of these products. Add 1 to 2 pt. crop oil. Limited data, use precaution. Add 1 pt. crop oil. Limited data, use precaution.
	ethephon + cyclanilide (Finish 6 Pro) + ONE OF THE FOLLOWING: tribufos (Def/Folex) thidiazuron + diuron (numerous brands) carfentrazone (Aim EC) pyraflufen ethyl (ET) flumiclorac (Resource) fluthiacet-methyl (Blizzard)	1.75 to 2 pt. + 8 to 12 oz. 6 oz. 1.0 oz. 1.5 oz. 4 to 6 oz. 0.5 to 0.6 oz.	 Limited data are available with some of these products. Add 1% v/v crop oil. Add 1% v/v crop oil. Add 1 to 2 pt. crop oil. Limited data, use precaution. Add 1 pt. crop oil. Limited data, use precaution.

PRECONDITIONING: Fields with a dense canopy of foliage and significant numbers of green bolls may require two applications. The goal is to remove much of the foliage with an initial application, exposing un-open bolls to sunlight and improving air circulation within the canopy. The follow-up application should be made 7 to 10 days later when sufficient leaf drop has occurred to allow spray coverage with boll opening products containing ethephon. However, premature preconditioning or defoliation may increase the risk of halting development of younger or immature bolls, rendering them unharvestable.

TREATMENT	PRODUCT COMMON NAME (BRAND NAME)	BROADCAST RATE/ACRE	REMARKS AND PRECAUTIONS **The rates below are given in the broadcast amount per acre unless otherwise noted.**
Initial Preconditioning Treatment	tribufos (Def/Folex)	0.5 to 1.25 pt.	
	ethephon (numerous brands)	0.67 to 1.33 pt.	
	glyphosate (numerous brands)	1.2 to 2 pt.	Glyphosate WILL NOT provide regrowth suppression when applied to RF cotton. See specific labels for product rates.
	pyraflufen ethyl (ET)	1.5 oz.	Add 0.5% v/v crop oil when temperatures are above 90°F. Add 1% v/v crop oil when temperatures are 89°F or below.
	carfentrazone (Aim EC)	1 oz.	Add 1% v/v crop oil.
	flumiclorac (Resource)	4 oz.	Add 1 to 2 pt. crop oil.
	fluthiacet-methyl (Blizzard)	0.5 oz.	Add 1 pt. crop oil
Follow-up Treatments	**Should include products containing ethephon with harvest aid mixtures listed in the previous table.**		

HARVEST AID WEED MANAGEMENT

PRODUCT COMMON NAME (BRAND NAME)	BROADCAST RATE/ACRE	REMARKS AND PRECAUTIONS **The rates below are given in the broadcast amount per acre unless otherwise noted.**
paraquat (Gramoxone Max, Firestorm, or Parazone) (Gramoxone Inteon)	 1 to 4 oz. 3 to 5 oz.	Use in combinations with standard defoliation applications. May cause crop desiccation and damage to unopened bolls.
glyphosate (numerous brands)	1.2 to 2 pt.	Use in combination with Def/Folex, dimethipen (Harvade) and/or ethephon. Glyphosate provides fair regrowth suppression of cotton. However, glyphosate WILL NOT provide regrowth suppression when applied to RF cotton. See specific labels for product rates.
carfentrazone (Aim EC)	1 oz.	Add 1% v/v crop oil. Effective on morningglory, coffee senna, and tropical spiderwort.
pyraflufen ethyl (ET)	1.5 oz.	Add 0.5% v/v crop oil when temperatures are above 90°F. Add 1% v/v crop oil when temperatures are 89°F or below. Effective on morningglory.
Follow-up Treatments (Desiccants) paraquat or sodium chlorate	See "Desiccants for Cotton Harvest Preparation" next page.	

DESICCANTS FOR COTTON HARVEST PREPARATION

DESICCANT COMMON NAME (BRAND NAME)	FORMULATION (lb. a.i./gal.)	BROADCAST RATE/ACRE (AMOUNT OF FORMULATION)	SPRAY VOLUME (gal./A)		REMARKS AND PRECAUTIONS **The rates below are given in the broadcast amount per acre unless otherwise noted.**
			Ground	Air	
paraquat					For addition to defoliant mixtures in cotton at least 75% open. Improves activitiy in colder, late-season conditions. May cause crop desiccation and damage to unopened bolls.
(Gramoxone Max)	3.0	1 to 4 oz.	10 to 20	5	
(Firestorm)	3.0				
(Parazone)	3.0				
(Gramoxone Inteon)	2.0	3 to 5 oz.	10 to 20	5	
paraquat					For desiccation of weeds and cotton regrowth after defoliation. Add surfactant at 1 to 2 qts. per 100 gal. of spray solution. Be prepared to harvest in a timely manner to minimize bark problems. May cause crop desiccation and damage to unopened bolls.
(Gramoxone Max)	3.0	5.5 oz. to 1.5 pt.	10 to 20	5	
(Firestorm)	3.0				
(Parazone)	3.0				
(Gramoxone Inteon)	2.0	1 to 2 pt.	10 to 20	5	
sodium chlorate	4 to 6	3 to 6 lb. a.i.	15 to 30	5 to 10	

PERFORMANCE RATING OF HARVEST AIDS BY FUNCTION

COMMON NAME (BRAND NAME)	FUNCTION				
	Removal of mature foliage	Removal of juvenile foliage	Boll opening	Regrowth suppression	Weed desiccation
PPO inhibitors (Aim, ET, Resource, Blizzard)	G	F	P	P	F
tribufos (Def/Folex)	G-E	P-F	P	P	P
thidiazuron (numerous brands)	G-E	G	P	G-E	P
thidiazuron + diuron (Ginstar/Adios)	G-E	G	P	G-E	P
ethephon (numerous brands)	F-G	F	E	P	P
ethephon + urea sulfate (First Pick)	G	G	E+	P	F
ethephon + cyclanilide (Finish 6 Pro)	G-E	F-G	E+	F	P
paraquat (Gramoxone Max, Gramoxone Inteon, Parazone, Firestorm)	F	F	P-F	P	G
sodium chlorate	F	P	P	P	F-G
P = Poor, F = Fair, G = Good, E = Excellent					

Harvesting

To do a good job, pickers must be in top condition before they go to the field. Replace any excessively worn or damaged spindles. The alignment and adjustment of spindles to moisture pads and doffers make a considerable difference in the efficiency of a cotton picker. Improperly adjusted spindles will allow some of the cotton to remain on the spindle, causing spindle twist and lower both quality and harvesting efficiency. A well adjusted picker will pick cotton with a minimum amount of trash, particularly bark. Picking units and basket grates should be cleaned each time the basket is dumped. The accumulated trash and low-quality fiber should be discarded and not mixed in with the good cotton.

Start pickers after dew dries and stop when dew forms. Use a meter to check the seed cotton moisture. If one is not available, bite the seed. If they crack, the moisture is probably low enough for harvesting. Cotton (lint, seed and trash combined) with a moisture content of 12 percent or lower can be harvested and stored satisfactory. Keep harvested seed cotton dry.

Modules

Several factors have an impact on the effectiveness of the moduling system. The most critical is moisture. As stated in the previous section, cotton should be harvested at or below 12 percent moisture. Wet cotton placed in a module lowers grades and creates serious ginning problems, in addition to potentially causing module fires. While the gin process involves drying, gins are mainly designed to remove moisture from lint not from seed. Wet, soft seed greatly reduces gin efficiency and may clog equipment. Cotton with excessive seed moisture may require the gin operator to pass the cotton through the drying system more than once, lowering ginning rate and increasing ginning costs.

Another major factor in the ability of a module to properly store seed cotton is the construction of the module. The tighter the module is packed, the better it sheds rainfall and the less seed cotton is lost during storage, loading and hauling. Modules should contain approximately 14 bales or 21,000 lb of seed cotton. Making modules too large causes handling problems. The top should be rounded so that water sheds after the module is covered. Depressions in which water can collect are sure to cause problems.

Site selection is another important aspect of the moduling system. In Georgia, many fields are not well suited to module placement, so planning should be done before picking begins. If custom operators are used, the responsibility of site selection and preparation should be discussed.

Placement

1. Place modules where water will drain away from the module. Do not place modules at the bottom of water ways.
2. The site should be free of gravel, stalks, and long grass. Prior to placement of modules stalks should be mowed and removed. Grassy areas should also be mowed and clippings removed. This may not seem important; however, grass or bark discounts can more than pay for time spent on site preparation.
3. If possible, place modules in a north/south position so the sun will hit both sides during the day.
4. Do not build modules in one location in the field and move to another. Each time a module is moved, it loses its firmness and shape.

Handling

1. Place modules on a firm surface accessible to trucks in wet weather.
2. Do not till the soil on the truck approach side of the module. The surface in front of the module needs to be firm for the module hauler to retrieve the module without stretching it.
3. Leave enough room in front of the module for the module hauler to get straight with the module for loading.
4. Place approximately 14 bales in the module. An excessive amount of cotton will cause a truck to be overweight, is hard on loading mechanism, and may contact the top of the truck.

Monitoring and Managing Modules

1. Record and monitor the temperature of modules for the first 7 days. If a temperature rise of 20^{o} F or a temperature of 120^{o} F is reached, gin the module as soon as possible.
2. If a storm occurs, check module tarps and remove any water that has collected on top of the module cover.
3. Check tarps for holes and tears. Replace any defective tarp.

New Technology

Both Case and John Deere have developed cotton pickers with on-board capacity to construct modules or something similar. Research is on-going to determine the increased efficiencies associated with these new technologies. Preliminary observations suggests that some types of these pickers may reduce waste, may reduce trash from soil , stubble or grasses, and may preserve some fiber quality characteristics.

CONSERVATION TILLAGE

Conservation tillage practices are employed on about 50 percent of the Georgia cotton acreage. In Georgia, conservation tillage and strip tillage are essentially synonymous. Incentives for such systems include reduced trips over the field, reduced labor and equipment costs, and soil and water conservation. After several years in reduced tillage, a slight buildup in overall organic matter often occurs, with significant increases in the upper half inch at the soil surface.

Success in conservation tillage requires a commitment to "make it work." Not surprisingly, there are pockets in the state of devotion to this methodology and adoption of the technology seems to grow more rapidly in these areas. Farmers gain confidence from watching successes on neighboring farms, and thus, are willing to attempt a significant change in production practices. Successful conversion to conservation tillage is rarely piecemeal, it requires a total change in equipment and management. Required equipment includes a strip till unit, sprayer, and hooded sprayer or high residue cultivator.

Historically, the greatest challenges of reduced tillage systems have been stand establishment and weed control. Strip tillage implements have eased the complications of obtaining a stand by creating an environment similar to conventional seedbed preparation. For reduced tillage systems, burndown herbicides replace preplant tillage as the means of eliminating vegetation.

The increased reliance on herbicides requires careful selection of products and rates as well as timely application.

Strip Till Equipment

Strip till equipment includes tillage implements which provide a narrow zone of tillage in the crop drill. These implements remove weed or cover crop debris, subsoil under the row, and provide a reasonable seedbed for planting cotton. Several brands are available, and possible options include variations in coulters and rear closing/mixing tools.

General Problems

Conservation tillage systems are not without problems. Success demands careful planning and management. In most situations, growers should begin a year in advance in preparations for changes to conservation tillage. Planting into residues or untilled surfaces requires use of specialized equipment and increased reliance on agrichemicals. Inclusion of cover crops may increase management and expense. In addition, cover crops may drain needed moisture in a dry year or retain excess moisture in a wet spring. Reduction in tillage may cause changes in pest complexes, for example, proliferation of certain perennial weeds. Weed control is further complicated by the inherent inability to incorporate dinitroaniline herbicides, which provide the backbone of annual grass and small seeded broadleaf control in conventional systems.

Soils

The presence of covers often results in slightly cooler soil temperatures, which may delay planting and/or increase seedling disease. Reduced tillage generally improves soil moisture, although the presence of covers may deplete soil moisture in a dry spring or conversely, retain excessive surface moisture in a wet spring. Either situation may delay or hinder cotton stand establishment. Though few trials have documented advantages of particular cultivars in conservation tillage, potential stresses of cool temperatures suggest the need for planting cultivars with good early season vigor.

Long term reduced tillage may cause compaction in some soils, but in others, soil tilth may increase. Significant increases in organic matter require continuous conservation tillage for at least 3 to 5 years. Shallow fall disking or chisel plowing smooths field surfaces, providing a level seedbed for subsequent spring planting of cotton. Long term use of controlled traffic patterns may eliminate the need for subsoiling every year.

Cover Crops

Use of seeded covers increases cost and management but with benefits of added surface residues, soil and water conservation, wind protection, and possibly grazing, seed production, or N fixation. For compliance purposes, surface litter must provide 30 percent cover of the soil immediately after planting to qualify as "conservation tillage." Cover establishment
can be accomplished by aerial seeding, spreading with fertilizer, or standard drill seeding in the fall. Cover crop establishment methods which do not include fall tillage, favor establishment of wind-dispersed, cool season weeds such as horseweed. In crops such as soybeans or cotton, aerial seeding prior to leaf drop aids in cover crop establishment. Seeding rates can be lower than used for forage or grain production; however, many growers suggest that full seeding rates are needed

to gain competitive advantage over weeds. In some situations, fallow or natural weed cover may be an economical alternative, provided they develop a sufficient winter cover.

Generally, small grain cover crops are easier to deal with than legumes. With high fertility, however, small grains may produce excessive growth, thus increasing problems with strip tillage and planting equipment and requiring slightly higher N rates (in cotton). In lower portions of the state, double crop wheat works in some years, although later planted cotton is at risk to early frost. Among the small grains, rye is probably the most adaptable. It is easiest to kill, easy to establish, and provides aggressive fall growth. In some instances, rye may provide too much vegetative growth and thus wheat may be a better choice. Ryegrass is extremely difficult to eliminate in the spring with burndown herbicides and should not be planted as a cover.

Though they may offset need for fertilizer N by about 30 lb/A, legumes pose several challenges. Legumes are often difficult to kill with burndown herbicides, and the release of ammonia during decomposition of green matter may injure cotton seedlings unless the cover is killed 2 weeks or more prior to planting. Legumes are also a host for cutworms and nematodes, the latter of which is a serious concern as increases in cotton acreage limit rotation. Most legume/conservation tillage systems have involved hairy vetch and crimson clover. In southern extremes and with early seeding varieties, crimson clover may work well in a reseeding program; in other words, clover may mature and produce seed prior to the time cotton should be planted.

Cover crops or weeds should be terminated with burndown herbicides 2 to 3 weeks before seeding cotton. Partial or strip killing of covers is usually not effective because of the competitive effects of the cover on the young cotton crop. Application accuracy of burn down sprays is facilitated by foam markers, light bars, or guidance systems. Termination of cover crops should be timed to limit excessive growth. This is of special concern with aggressive covers such as rye. Though research is not very precise on the matter, rye should be terminated before it reaches 3 to 4 ft tall, other small grains before they exceed 2 to 3 ft. The key is to desiccate the cover to prevent excesses in dry matter production and complications with strip tillage and soil/seed contact at planting.

Fertility

Because of limited opportunity to correct problems, a move into conservation tillage should begin only after establishing proper pH and fertility. Surface applications of lime and fertilizer are adequate for maintaining nutrient levels in reduced till systems. Starter fertilizers may have greater utility in conservation tillage because of cooler or compacted soils and the inability to thoroughly mix fertilizer amendments. Nitrogen fertility must be integrated with cover crop management--increase N rates for small grains, decrease for legumes--and petiole testing may be even more valuable in conservation tillage than in conventional tillage systems.

Strip Tillage/Planting

Achieving an adequate crop stand is foundational for successful cotton production. In conservation systems, strip tillage and planting equipment must effectively operate in surface litter and narrow, tilled zones to place cotton seed in firm contact with moist soil at a desired

depth. Fortunately, manufacturers and farmer-innovators have developed numerous implements for planting in reduced tillage situations.

Strip tillage and planting may be performed in the same or separate operations, with advantages for either approach. If both are performed in the same pass, there are fewer tracking problems and obvious savings in equipment and labor. Delaying planting 10 days or more after strip tillage reduces problems associated with litter decomposition and allows for moisture recharge of the tilled seedbed.

Rain or timely irrigation overcomes poor planting technique and poor soil/seed contact. Planting in a depression should be avoided because of potential problems with preemergence herbicide injury, postemergence weed control, and harvest. Standard strip tillage practices are not readily suited to establishment of raised beds and smooth row shoulders. However, a few growers have had success with fall bedding followed by cover seeding in order to create beds for the subsequent planting of cotton.

Insect Management

Insect management in conventional and reduced tillage systems is similar for most insect pests. However, differences do exists, most notably is the increased risk of cutworms in reduced tillage systems, especially if a legume cover crop is used. To reduce the risk of cutworm attack cover crops or winter weeds should be **controlled at least three weeks prior to planting**. No green vegetation should be present at planting, as it may serve as a reservoir host for various insects which may infest cotton. If the risk of cutworm infestation is high (i.e. green vegetation present, legumes cover crop, etc.), consider banding a cutworm insecticide such as a pyrethroid behind the planter as a preventive treatment. Increased infestations of false chinch bugs are sometimes observed in reduced tillage systems when a timely burndown herbicide was not applied. Grasshoppers are also more common in reduced tillage systems. We tend to observe fewer thrips in conservation tillage systems, but a thrips management program will still be needed. As fields remain in conservation tillage for several years, fire ants (beneficial) tend to increase.

Disease Management

Cooler temperatures and decaying vegetation contribute to increased potential for seedling disease in conservation tillage. Delaying planting or separating strip tillage and planting typically results in warmer, more favorable conditions and thus may aid in stand establishment in reduced till systems.

The interaction of covers with nematodes is not fully understood, but the preference of nematodes for certain legumes raises questions about their long term use in conservation tillage cotton. This is especially true for clovers and vetches.

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ATTENTION!
PESTICIDE PRECAUTIONS

1. **Observe all directions, restrictions and precautions on pesticide labels. It is dangerous, wasteful, and illegal to do otherwise.**
2. **Store all pesticides in original containers with labels intact and behind locked doors. "KEEP PESTICIDES OUT OF THE REACH OF CHILDREN."**
3. **Use pesticides at correct label dosage and intervals to avoid illegal residues or injury to plants and animals.**
4. **Apply pesticides carefully to avoid drift or contamination of non-target areas.**
5. **Surplus pesticides and containers should be disposed of in accordance with label instructions so that contamination of water and other hazards will not result.**
6. **Follow directions on the pesticide label regarding restrictions as required by State or Federal Laws and Regulations.**
7. **Avoid any action that may threaten an Endangered Species or its habitat. Your county Extension agent can inform you of Endangered Species in your area, help you identify them, and through the Fish and Wildlife Service Field Office identify actions that may threaten Endangered Species or their habitat.**

Crop & Soil Sciences

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The University of Georgia College of Agricultural and Environmental Sciences