2017
GEORGIA COTTON PRODUCTION GUIDE

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

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THE 2016 CROP YEAR IN REVIEW

Over the past few years, each cotton production season in Georgia has been considered unique because of weather patterns and issues and decisions producers have been faced with. The 2016 season followed that same pattern as weather in the growing season was significantly different and new challenges and opportunites became apparent for producers in 2016 which will likely impact the future of Georgia cotton. With an estimated 1,170,000 acres harvested in 2016 (USDA NASS), Georgia remains the 2nd largest cotton producing state in the union, second only to Texas. From a historical perspective, Georgia producers have remained commited to planting cotton compared to other states across the belt. Planted acres in 2016 (1,180,000) were up from 2015 (67,000 acres), yet only slightly down from the previous five-year aveage (1,354,000).

The predominant defining factor describing the 2016 season was the generally hot and dry growing season. According to the United States National Oceanic and Atmospheric Administration (NOAA), average temperatures in Georgia during the growing season in 2016 (May thru September) were the fourth highest on record (with records back to 1985). July was the third hottest on record and August was the eighth hottest on record. During that same period (May thru September) 2016 was also the nineth driest on record in Georgia.

In particular, the 2016 cotton growing season started with relatively warm air and soil temperatures in late April, which allowed for the earliest of the crop to get off to good start. In early May significant rainfall feel across most of the cotton growing regions in Georgia which provided good soil moisture for dryland crop emergence. However, the rest of May consisted of significant heat and dry weather with only few scattered, yet heavy, rains. This weather impacted stand emergence and increased incidence of seedling disease negatively impacted stands. Premergence herbicides are still a staple of Georgia cotton production and injury from those applications was similar to previous years, yet more than usual cases of herbicide injury occurred from splashing rains which moved soil into contact with stems and buds allowing for significant injury. In eastern parts of Georgia, rain which fell in late May delayed the latest planted acres as rainfall totals reaching 10 or more inches kept producers at bay and leached some fertilizer applications already made.

Most of the state was relatively hot and dry durng the end of May to the end of June, as most producers received significant rainfall on the last week of June. This pattern continued throughout the summer and as mentioned rainfall was typically less than adequate during the entire growing season. However, two significant tropical systems impacted the crop. The system “Hermine” made landfall during the first week of September and brought significant rainfall to much of south Georgia (over 4” in Tifton and Statesboro) and delivered heavy winds in its path (from Tallahasse, FL to Savannah, GA) which twisted and lodged cotton stalks in many fields. In early October, “Matthew” swept across the eastern part of Georgia and again brought significant rainfall in south east Georgia (over 6” in Statesboro). Hurricane Matthew also delivered high winds which significantly impacted cotton fields in eastern counties where the crop was nearing or ready for harvest. These winds blew cotton from harvestable bolls off the plant and reduced yields and the impact on yield was extremely variable depending upon how close to harvest the particular field was (some fields had negligible losses, yet in what was likely a worst case scenario one field in Tattnall county had documented reaching 550 pounds of lint per acre). Other than issues from Hurricane Matthew, the harvest season was exceptional, as many fields received little or no rainfall from the time when bolls started opening until harvest. Most of the state was considerably dry until the first of December.

The most common challenges for growers in 2016 included stand establishment, thrips, nematodes, glyphosate-resistant Palmer amaranth, and boll rot and hardlock related to weather late in the growing season. Seedling vigor is something that most growers in Georgia consider, yet much of the crop has recently been planted to smaller seeded varieties which may complicate stand establishment where seeding rates are utilized which lower seed costs per acre and create small "margins of error". Some producers who have encountered issues more often than others have started to play closer attention to seedling vigor of varieties. Overall, thrips have become a significant issue for most producers and lack of control from seed treatments has some concerned. Producers have started to actively manage this pest with seed treatments, in-furrow insecticides, and even with Alidicab which was produced and sold in Georgia for the first time in several years (AgLogic). Bacterial leaf blight was found in most areas of the state in 2016, which created much concerns for growers because it showed up in a lot of areas for the first time in many years. The 2016 cotton acreage in Georgia was predominately planted with Deltapine (70.3%) and Phytogen varieties (16.9%). Market share of other brands was 6.6% for Stoneville, 2.2% for Americot, 2.1% for Croplan Genetics and 1.2% for FiberMax (Cotton Varieties Planted 2016 Report – USDA). There was significant movement in the particular varieties which growers planted as over 63% of Georgia's acreas were planted to varieties released in 2015 and 2016. Overall, DeltaPine varieties were widely planted, and the stacked dicamba, roundup, liberty herbicide technology (Xtendflex) from Monsanto was widely adapted even though applications of the herbicide dicamba were not allowed for 2016. Varieties with the Xtendflex techonogy were released for sale in 2015 and they were planted on an estimated 684,000 acres in Georgia (58% of acres in 2016, 19% in 2015 and 0% in 2014).

Cotton yields were variable as always in Georgia during 2016, yet many producers were left with the feeling that 2016 was a "down year". The significant hot and dry conditions were likely culprits in dryland fields and even in irrigated fields. The state-wide aveage yield for Georgia in 2016 was 903 lb/A, which compared to the record year of 2012 (which averaged 1091 lb/A) was down. However, considering the significant challenges growers faced in 2016 903 lb/A was only 10 lb/A off from the previous five-year average and marks only the fourth year on record where average yields were over 900 lb/A.

Although yields are variable depending upon rainfall during the each season, average statewide yields continue to rise. Over the past 15 years, yields in Georgia have increased by an average of 3.4 percent each year and by 50 percent during the entire period, which is a true testament to Georgia's growers, their commitment to cotton, and the release of superior varieties. As modern varieties are currently being released onto the market in a much more rapid manner, due to increased competition and advancements by industry, variety selection remains a very important and costly issue.

Quality of the cotton crop in Georgia in 2016 was incredible, in fact record breaking. Because of the harvest season, color grades were outstanding as 96% of the crop was 41 or better color grade. The new cotton varieties that producers are planting are significantly improving other parameters as well. In 2016, the state-wide averages in fiber length, strength and uniformity all were at record highs. All things considered, the estimated loan value of Georgia's 2016 crop was over 56 cents per pound (using average color grade, leaf, micronaire, staple length, strength and uniformity from the Macon classing office reports).

Fiber Quality of Bales Classed by December 31st at the Macon USDA Classing Office, 2008-2016

Year	Color Grade 31/41 or better (% of crop)	Bark/ Grass/ Prep (% of crop)	Staple (32nds)	Strength (g/tex)	Micronaire	Uniformity
2008	25 / 93	all < 1.0	34	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	81.0
2011	38 / 84	3.0 / <1 / 1.0	36	29.6	46	81.7
2012	46 / 91	12.4 / <1 / <1	36	29.1	47	81.5
2013	57 / 98	5.7 / <1 / <1	35.9	29.7	48	81.7
2014	62 / 87	3.4 / <1 / <1	35.6	29.0	47	81.3
2015	16 / 54	2.3 / <1 / 5.2	36.0	29.0	47	81.6
2016	82 / 96	3.1 / <1 / <1	35.9	29.8	47	82.0

Bales classed short staple (< 34) and high mic (>4.9)
2008: 16% & 21% 2009: 5% & 20% 2010: 16% & 9% 2011: 4% & 8.8%
2012: 1.4% & 20.5% 2013: 1.1% & 30.1% 2014:5% & 18.1% 2015: 2% &17.3%
2016: 5% & 19%
Source: http://www.ams.usda.gov/AMSv1.0/

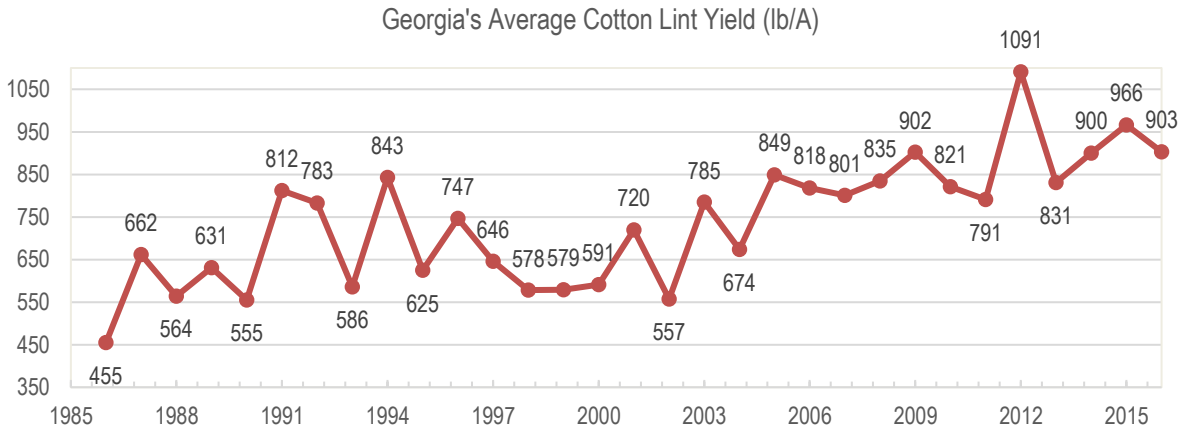


Figure 1. Georgia's state-wide average yield (lbs/A) over the past 30 years. (USDA NASS)

ECONOMIC ISSUES, CONSIDERATIONS, AND OUTLOOK FOR 2017

Georgia cotton growers planted 1.19 million acres of cotton in 2016—up 60,000 acres from 2015. While acreage has been down and has fluctuated from the modern-day record high of 1.6 million acres in 2011, cotton has proven to be a stable enterprise for Georgia agriculture. This is largely due to the lack of consistently profitable alternatives (with the exception of peanuts), rotation limitations on peanuts, and producer investment in cotton infrastructure (ginning). Acres planted has averaged 1.272 million acres since the record in 2011—varying only +/- 142,000 per year on average.

For 2015 and again for the 2016 crop, the cash market basis has been strong here in the Southeast and fiber quality premiums have also been very good. For 2016, 83% of the Georgia crop graded Color 31 or better and 81% graded staple 35 or longer—61% staple 36 or longer. Fiber quality, especially Color grade, was enhanced by excellent harvest conditions but Georgia growers are also benefiting from good yield and fiber quality potential of varieties planted.

Price Situation and Outlook for 2017

Prices for 2017 cotton (Dec17 futures) are currently around 69 to 70 cents. This is about 1 cent less than current old crop (2016 crop) futures prices. Dec16 futures for the 2016 crop were mostly below 65 cents during the planning and planting period and did not reach 69 cents or better until July. So in comparison, prices for the 2017 crop are higher than at this same time last year.

Price drivers for the 2017 crop will be those that were also important for the 2016 crop. This will include US and World production, the level and change in World stocks, demand or mill use of cotton, and ultimately how all these factors determine the amount and pace of US exports.

The US produced 16.52 million bales in 2016—3.6 million bales more than 2015 due to a 20% increase in acres harvested and higher yield. US exports for the 2016 crop year are projected to be 12.2 million bales—up just over 3 million bales from 2015. The increase in exports is due to more available supply and the good quality of the US crop. This level of exports is especially good considering that China for the second consecutive year is limiting imports. The good level of exports has helped stabilize prices.

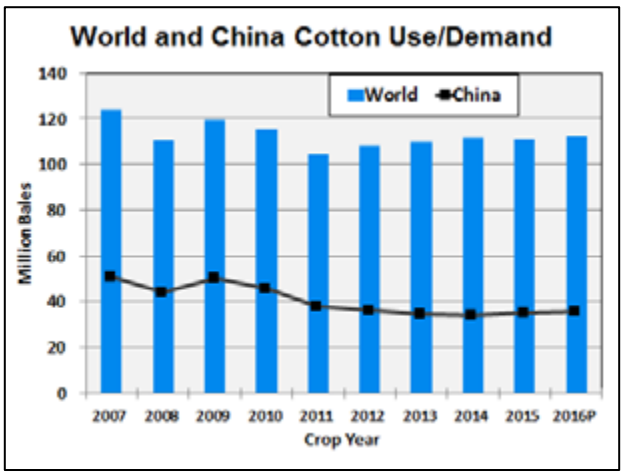
At this time, it seems probable that US cotton acreage could increase slightly in 2017. This is based on the principle of "relative" prices. The Mid-South states in particular will shift acres based on prices for corn and soybeans. Corn price is up compared to last spring but cotton is also up and has increased more relative to corn. Soybean price is also up but cotton has gained ground relative to soybeans. But care must be taken in this approach. Cotton growers know that the loan LDP/MLG insulate them from low prices (when cotton is roughly 65 cents and less). So, last year's cotton prices below 65 cents or even 60 cents during the planning and planting time may not be meaningful in decision-making. In peanut-producing states, peanuts could attract additional acres in 2017. If US cotton acreage and production increase in 2017, price direction will be even more dependent on improving demand/use for cotton and US exports and market share.

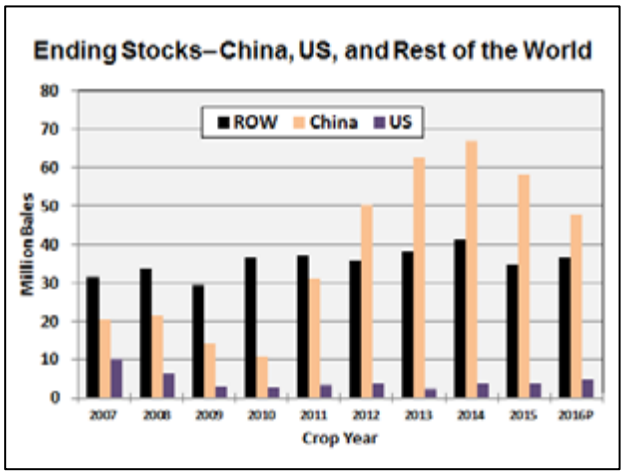
World cotton area and production has trended down in recent years. China's production has dropped by one-third. China's mill use of cotton has declined and China has cut production, limited imports, and utilizing its stocks.

China auctioned off over 12 million bales of its government reserve stocks in 2016—3 million bales more than was originally targeted for sale. Given uncertainties about fiber quality and pricing, sales went much better than expected. Another round of sales is scheduled for 2017. These sales will impact 2017 price direction. China's stocks, while still large by historical measure, are expected to decline by 19 million bales from the peak in 2014 by end of the 2016 crop marketing year.

World use/demand for cotton is slowing improving. This can be attributed in-part to the sale of China stocks which seems to have sparked more use of cotton in its mills. World cotton use is projected to tick up just slightly (.6%) for 2016-17. China is forecast up 750,000 bales (up 2.1%). Particularly with still large World and Chinese stocks, increased cotton prices cannot be sustained with stronger growth in demand. Stocks are moving in the right direction (shrinking) but unless supply shocks occur, prices will be demand-driven and demand need to grow.

With less stocks and demand at least stabilizing, the foundation could be set for better prices for the 2017 crop. Futures prices for the 2017 crop are already 5 to 10 cents better than last year this time. Given the volatility and uncertainty of this market, beginning marketing decisions at 70 cents or better on at least some small portion of expected 2017 production seems prudent.





Comparison of Expected Net Returns

The tables below provide early/preliminary estimates of per acre net returns for 2017. These estimates are based on harvest-time futures prices as of mid-December 2016 for corn, cotton, and soybeans and expected average contract and harvest price for peanuts. As such, these comparisons are best used simply as a current ranking of enterprise net returns as prices and costs will change.

For non-irrigated production and based on prices, estimated costs, and assumed average yield, peanuts are projected to have the highest per acre net return, followed by cotton, soybeans, and corn. At $430/ton for peanuts, cotton would have to be 80 cents to provide equal net returns. At 71 cents for cotton, peanuts must be at least $389/ton to provide an equal or higher net return than cotton.

Preliminary Comparison of 2017 Per Acre Net Returns, Non-Irrigated Production

	Corn	Cotton	Peanuts	Soybeans
Expected Average Yield	85	750	3,400	30
Expected Average Price [1]	$4.15	$0.71	$430	$9.50
Crop Income	$353	$533	$731	$285
Variable Costs [2]	$293	$414	$542	$197
Net Return	**$60**	**$119**	**$189**	**$88**

1/ Prices are basis the harvest-time futures as of mid-December 2016. Peanut price is based on expected average contract price and harvest price.

2/ Average of conventional and strip-till production. Excludes land rent. Preliminary estimate based on adjustments from 2016 cost estimates.

Preliminary Comparison of 2017 Per Acre Net Returns, Irrigated Production

	Corn	Cotton	Peanuts	Soybeans
Expected Average Yield	200	1,200	4,700	60
Expected Average Price [1]	$4.15	$0.71	$430	$9.50
Crop Income	$830	$852	$1,011	$570
Variable Costs [2]	$562	$503	$620	$267
Net Return	**$268**	**$349**	**$391**	**$303**

1/ Prices are basis the harvest-time futures as of mid-December 2016. Peanut price is based on expected average contract price and harvest price.
2/ Average of conventional and strip-till production. Excludes land rent. Preliminary estimate based on adjustments from 2016 cost estimates.

For irrigated production and again based on prices, estimated costs, and assumed average yield, peanuts are projected to have the highest per acre net return, followed by cotton, soybeans, and corn. The margin of difference between peanuts and cotton is less than in non-irrigated production, however. At $430/ton for peanuts, cotton at 74½ cents would provide equal net returns. At 71 cents for cotton, peanuts must be at least $412/ton to provide an equal or higher net return than cotton.

Comparative net returns for both irrigated and non-irrigated suggest that cotton and peanuts may attract acres from corn and soybeans. Most farm businesses, however, are probably on a fairly stable crop mix and rotation although, to the extent possible, acreage planted can be tweaked based on market signals.

Generic Base

Cotton base on a farm under the 2008 farm bill is now Generic Base. Cotton is not a "covered commodity" and not eligible for ARC/PLC. Thus, cotton base on a farm would have no value if not for the Generic Base provision. On a farm with Generic Base (former cotton base), if "covered commodities" are planted, those acres up to the amount of Generic Base are "assigned" to the Generic Base and are treated as Temporary Base in addition to any Permanent Base of the crop on the farm. Both Temporary Base and Permanent Base are eligible for ARC/PLC.

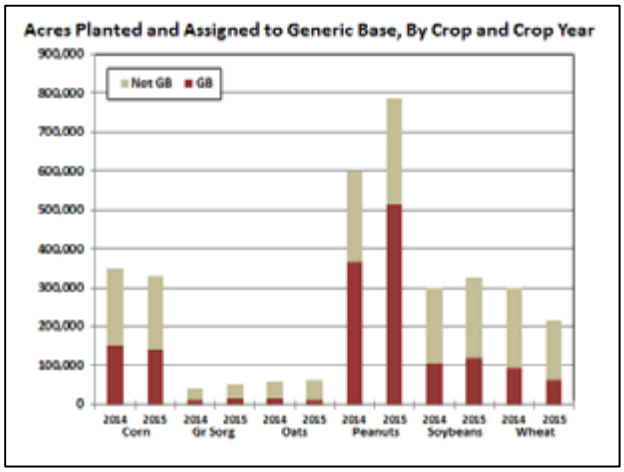
Generic Base on Georgia Farms and Covered Commodities Planted and Assigned to Generic Base, Earning Temporary Base

		Acres Planted to Covered Commodities and Assigned to Generic Base [2]										
	Generic Base [1]	Barley	Canola	Corn	Grain Sorghum	Oats	Peanuts	Sesame	Soybeans	Sunflower	Wheat	Total
2014 Ac	1,530,589	128	1,721	153,181	10,826	12,921	366,494	499	105,238	987	93,581	745,576
2014 Pct		.017	.23	20.5	1.45	1.73	49.16	.067	14.11	.132	12.55	
2015 Ac	1,529,744	1	2,544	144,194	14,961	12,749	513,836	699	118,608	715	63,307	871,614
2015 Pct		<.001	.292	16.54	1.72	1.46	58.95	.08	13.61	.082	7.26	

1/ Source: USDA Farm Service Agency, www.fsa.usda.gov/programs-and-services/arcplc_program/index, "2014 and 2015 Base Acres By County", Dec 19, 2016.
2/ Source: USDA Farm Service Agency, www.fsa.usda.gov/programs-and-services/arcplc_program/index, "2015 and 2014 Crops Planted on Generic Base Acres", Dec 19, 2016. Percent is the percent of Total acres planted/assigned to Generic Base.

In 2014, the first crop year of the new farm bill, Georgia had 1.53 million acres of Generic Base. Of this amount, 745,576 acres (49%) was planted to covered commodities and earned temporary base. Most of these acres planted were peanuts. The 2014 farm bill (effective for the 2014-2018 crop years) was not signed into law until February 7, 2014. Because of the then lengthy process of implementing the rules and regulations by USDA, producers and landowners did not/could not make payment yield, base, and ARC/PLC decisions until late 2014 and into mid-2015.

Certainly for the 2014 crop and possibly even for the 2015 crop, the Generic Base provision was not fully understood and planting decisions affected by this. Additionally, the 2014 crop had already been harvested before the ARC/PLC decision retroactive to the 2014 crop had to be made. For the 2015 crop year, 871,614 acres (57% of the Generic Base), was planted and assigned to Generic Base. Again, most acres planted (59%) were planted to peanuts.



In 2014, Georgia farmers planted 600,000 acres of peanuts. Of that amount, 61% was planted and assigned to generic base. In 2015, 65% of the 785,000 peanut acres planted were assigned to generic base. In 2014 and 2015, 44% of corn planted was planted on farms with generic base. Over the two years, approximately 28% of grain sorghum planted, 20% of oats, 36% of soybeans, and 30% of wheat has been planted and assigned to generic base.

Plantings on generic base increased in 2015. This was due to the increase in peanut acreage. Generic base is former cotton base—the historical average acres planted as defined in the 2008 farm bill. Most farms that grow cotton also grow peanuts and vice versa. Therefore, it makes sense that peanuts are the covered commodity most planted on generic base. Whether it be peanuts or any covered commodity, the economics of generic base is simply that if a farm business intends to plant a covered commodity and the business has farms (FSN's) with generic base, the covered commodity should be planted on that farm—to the extent that crop rotation and good management practices will allow.

Crop Insurance and STAX

STAX is a county/area revenue policy and is the farm bill safety net for upland cotton. STAX may be purchased alone or in combination with an underlying companion policy (CAT, yield, or revenue). STAX was not implemented until the 2015 crop. In 2015, 29.9% of US upland cotton acres were enrolled in STAX. For 2016, several modifications were made to STAX including the option of selecting 0% coverage by practice (choosing to insure non-irrigated but not irrigated, for example and the addition of area yield protection for cottonseed. For 2016, enrollment in STAX was 25.6%. In 2015, 41.6% of Georgia cotton acres planted were insured with STAX. Most of these acres were also insured with a companion policy. In 2016, STAX participation in Georgia was still well above the national average but declined to 37.7%.

Crop Insurance, Cotton Acres Enrolled by Policy Type, Georgia [1]

	2015		2016	
	Acres	Percent [2]	Acres	Percent [2]
Yield Protection	197,951	17.52	204,942	17.22
Revenue Protection	742,979	65.75	776,259	65.23
CAT	127,825	11.31	142,931	12.01
STAX- Stand Alone	9,308	.82	7,724	.65
STAX- With Companion Policy	460,538	40.76	441,095	37.07
Total Acres Insured [3]	1,078,063	95.40	1,131,856	95.11

1/ Source: USDA Risk Management Agency, www.rma.usda.gov/data/sob.html, Summary of Business- "National Summary by State/Crop", Dec 19, 2016.

2/ Percent of acres planted—1.13 million acres planted in 2015, 1.19 million acres planted in 2016. Source: USDA-NASS.

3/ Excludes STAX with a companion policy.

In both years, all STAX policies sold in Georgia were with the harvest price option. For the 2015 crop, STAX paid in 18 Georgia counties. For 2015, the Projected Price and Harvest Price were the same—so any indemnity received would have been on the basis of county/area yield only. The table below shows random but geographically spread examples of a few counties where STAX paid and where it did not.

For the 2016 crop, the Projected Price was 62 cents and Harvest Price 69 cents. Final Area Yields have not yet been determined. The table below shows the "Loss Threshold" that can already be calculated based on Expected Yield and prices and assuming a 90% Loss Trigger. Dividing the Loss Threshold by the Harvest Price, the "Breakeven Final Yield" can be determined. For these counties, for STAX to pay, the Final Yield must be less than this amount. The table shows a few random but geographically spread example counties. Producers who purchased STAX for 2016 and asking if STAX will pay, may wish to do similar calculations for their situation.

2015 Crop STAX Examples—Yield, Guarantee, and Indemnities Paid
Projected Price $0.63, Harvest Price $0.63, 90% Loss Trigger, PF 1.1

	Appling		Burke		Colquitt		Dooly		Seminole	
	Non-Irr	Irrigated	Non-Irr	Irrigated	Non-Irr	Irrigated	Non-Irr	Irrigated	Non-Irr	Irrigated
Expected Yield	754	1,073	642	1,117	856	1,163	688	1,193	653	1,229
Expected Revenue [1]	$475.02	$675.99	$404.46	$703.71	$539.28	$732.69	$433.44	$751.59	$411.39	$774.27
Loss Threshold [2]	$427.52	$608.39	$364.01	$633.34	$485.35	$659.42	$390.10	$676.43	$370.25	$696.84
Final Yield	807	1,163	416	1,070	853	1,290	934	1,270	547	1,223
Final Area Revenue [3]	$508.41	$732.69	$262.08	$674.10	$537.39	$812.70	$588.42	$800.10	$344.61	$770.49
Area Loss [4]	$0.00	$0.00	$101.93	$0.00	$0.00	$0.00	$0.00	$0.00	$25.64	$0.00
Indemnity Paid [5]	$0.00	$0.00	$88.98	$0.00	$0.00	$0.00	$0.00	$0.00	$28.20	$0.00

1/ Assumes harvest price option. Expected Revenue is Expected Yield times the Projected Price. With the harvest price option, however, the "Revenue Used for Loss Calculation" is the Expected Yield times the higher of Projected Price or Harvest Price. This revised amount would be shown and used here if Harvest Price is higher.
2/ Assumes 90% loss trigger. Revenue Loss Threshold is Expected Revenue times the loss trigger. STAX pays if Final Area Revenue is less than this amount.
3/ Final Yield x harvest price
4/ Loss Threshold minus Final Area Revenue if Final Area Revenue is less than the Loss Threshold; otherwise zero.
5/ Assumes 20% coverage range (90-70%). Indemnity paid is the lesser of Area Loss or 20% of Expected Revenue, times the PF (Protection Factor)

2016 Crop STAX—Example Assessments of the Likely Indemnities
Projected Price $0.62, Harvest Price $0.69, 90% Loss Trigger

	Bulloch		Jeff Davis		Miller		Pulaski		Worth	
	Non-Irr	Irrigated	Non-Irr	Irrigated	Non-Irr	Irrigated	Non-Irr	Irrigated	Non-Irr	Irrigated
Expected Yield [1]	829	1,138	769	1,160	634	1,170	709	1,150	763	1,229
Projected Price [2]	$0.62	$0.62	$0.62	$0.62	$0.62	$0.62	$0.62	$0.62	$0.62	$0.62
Harvest Price [2]	$0.69	$0.69	$0.69	$0.69	$0.69	$0.69	$0.69	$0.69	$0.69	$0.69
Expected Revenue [3]	$572.01	$785.22	$530.61	$800.40	$437.46	$807.30	$489.21	$793.50	$526.47	$848.01
Loss Trigger	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%
Loss Threshold [4]	$514.81	$706.70	$477.55	$720.36	$393.71	$726.57	$440.29	$714.15	$473.82	$763.21
BE Final Yield [5]	746	1,024	692	1,044	571	1,053	638	1,035	687	1,106

1/ Source: USDA Risk Management Agency, Information Browser, https://webapp.rma.usda.gov/apps/actuarialinformationbrowser/
2/ Source: USDA Risk Management Agency, Price Discovery, http://prodwebnlb.rma.usda.gov/apps/PriceDiscovery
3/ Assumes harvest price option. Expected Revenue is Expected Yield times the Projected Price. With the harvest price option, however, the "Revenue Used for Loss Calculation" is the Expected Yield times the higher of Projected Price or Harvest Price. This revised amount is shown here because Harvest Price is higher.
4/ Assumes 90% loss trigger. Revenue Loss Threshold is Expected Revenue times the loss trigger. STAX pays if Final Area Revenue is less than this amount.
5/ "Breakeven" Final Yield equals the Threshold divided by the harvest price. Final Yield must be less than this amount to trigger an indemnity.

Cotton Program and Farm Bill Issues

Under the 2014 farm bill, the Loan Rate for cotton is now allowed to vary between 45 and 52 cents per pound. The Loan Rate is the average Adjusted World Price (AWP) for the most recently completed 2 crop years but cannot go below 45 cents/lb or above 52 cents/lb.

The base Loan Rate for 2017 will be 49.49 cents/lb—down 1.51 cents from the 52 cents rate for 2016. This has several implications. First of all, for producers and marketing associations that use the loan as a marketing tool, it means less cash-flow up front. Second, any LDP or MLG will be 1.51 cents per lb less than it otherwise should be if prices dip low enough to trigger one. The loan rate determination and formula may be subject to discussion and change in the next farm bill. A 2-year average tied to the AWP may not provide protection during periods of prolonged low prices.

The proposal by cotton industry leadership to make cottonseed eligible for ARC/PLC is not dead. Proponents in industry and in Washington continue to press for this as a way to improve the safety net for cotton. Discussion seems to be centering on when and how this needs to be done—before the next farm bill or as part of the next farm bill.

The continuation of the Generic Base provision in the next farm bill is also a debate. If Generic Base is eliminated, it will be especially vital to have "cottonseed base" and program eligibility as a replacement.

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 to between 6.0 and 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 call for resampling.

Dolomitic lime (that has 6 % or more Mg) is still a common liming material used on Georgia cotton and provides magnesium (Mg) as well as calcium (Ca) and a pH adjustment. The use of **calcitic lime** (less than 6% Mg) is becoming more popular in Georgia every year 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 continue to occur in Georgia cotton every year.). 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 not be an issue. **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.

Because current cotton varieties are relatively fast fruiting and early in maturity, 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.

Also, the practice of applying P and K fertilizer for Georgia cotton in the fall ("**fall fertilization**") is not recommended due to the chance of leaching K below the root zone on deep sands with adequate winter rainfall. Nitrogen is highly mobile and should not be applied in the Fall. Fall fertilization of P only would be acceptable however there are very few "P only" fertilizer materials (that do not contain some N and/or K) presently available to Georgia cotton growers.

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 next.

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 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**. No N should be soil-applied (either top dressed or through the pivot) after the 3rd week of bloom.** Studies have shown that uptake of soil-applied N from by cotton roots is basically ineffective after this crticial point.

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 that contains the active ingredient NPBT. 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 between 2010 and 2012 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!**

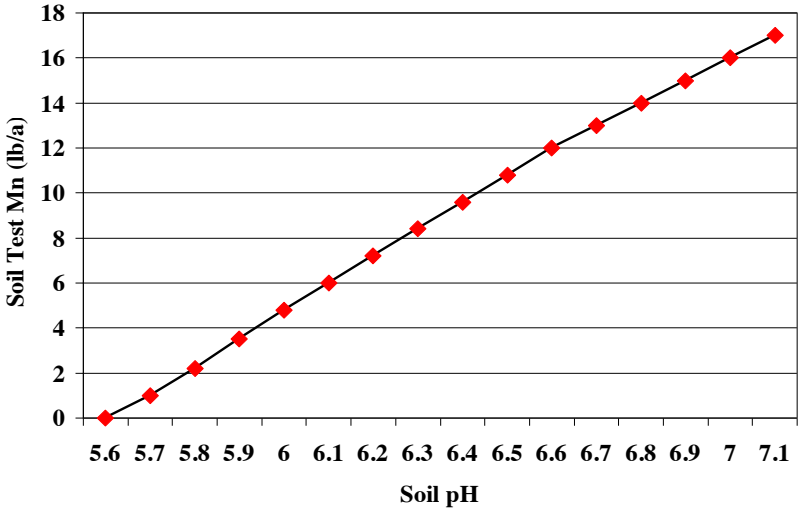
Manganese and Zinc

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 pH. 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.

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.

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



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 and soybeans 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 (Mehlich 1 extractant). 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 Georgia cotton are extremely rare.

Petiole and Tissue Testing

The University of Georgia used to offer 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) were 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 was recommended. Potassium levels were 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 was that weekly sampling tracked nutrient level trends and allowed the detection of deficiencies or excesses up to 2 weeks in advance. Due to labor and time costs, Georgia cotton growers were not utilizing the 10-week petiole testing program at UGAand therefore it has been discontinued.

Petiole testing for troubleshooting is still available and can still be a valuable tool for making in-season correction of certain nutritional problems (namely N and K). "Spot checking" with petiole sampling can be done as many weeks during the fruiting period as desired. Simply sample the petioles and send them to the UGSA lab for analysis and a recommendation of where the typical nitrate and K levels should be for that week of bloom.

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 is more important for correcting nutritional problems prior to bloom and can detect different nutritional problems such as with magnesium, sulfur manganese and zinc. 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. Feed grade 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.

Based on field research trials, foliar fertilization is most effective when applied during peak bloom or the first 4 weeks of bloom. Foliar feeding during the 5^{th} – 7^{th} weekof bloom may or may not be effective depending on the particular coptton variety grown**. How late is too late to foliar feed cotton? Once you pass the 8^{th} week of bloom**, it is too late and no foliar feeding is recommended.

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. By using current fertilizer prices, producers may calculate the value of a ton of poultry litter. This value would normally be calculated by the N, P and K in the litter, if soil test P is high and no P is called the value of litter would be lower. Also to consider it that this value also **does account for** the lower availability of N compared to commercial fertilizer (60 % compared to 100 %). 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 and has not been that prevalent in recent years. 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.

How early can I apply chicken litter for cotton? In general, it is best to apply any base fertilizer nutrient (inorganic/commercial or organic like chicken littler) close to when a plant needs it, typically 2- 3 weeks before planting. Therefore, ideally, chicken litter would not be applied until around April 1 for May planted cotton. Timing of acquiring litter and availability of labor tempts growers to apply litter as early as December and January. This is not recommended since most of the N and some of the K can be lost before the cotton crop will ever be established (depending on soil type and rainfall). In addition, if a cover crop is grown, the cover crop will take up the nutrients from the litter and greatly decrease the availability to the cotton crop. **If at all possible, delay applying chicken litter for cotton until at least February 1.**

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. There are many techonolgy systems and packages that will be available in 2016. The predominant technology systems that will be available in 2016 include (but aren't necessarily limited to) conventional, Bollgard II Roundup Ready Flex (B2RF), Widestrike Roundup Ready Flex (WRF), Glytol Liberty Link TwinLink (GLT) Bollgard II Xtendflex (B2XF) and Widestrike 3 Enlist (W3FE). In variety "names" there is a set of letters after the name which designate techonologies (See table below). For example, DP 1538 B2XF is a variety which has the Bollgard II Xtendflex technologies and therefore has a two-gene bt trait and herbicide tolerance to glyphosate, glufosinate and dicamba. It is generally advised that growers should strongly consider spreading their risks by planting multiple varieties. A single dominant variety is unlikely, however official variety trials and on-farm county variety trials in 2010-2013 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 and degree/efficiency of irrigation), maturity classes, and plant growth characteristics, with the understanding that some varieties may perform better in certain situations than others.

Guide to Abbreviations for Cotton Technologies in Variety Nomenclature*

Abbreviation	Trait Name	Description
W	Widestrike	Two-gene insect trait (Cry1Ac + Cry1F)
W3	Widestrike III	Three-gene insect trait (Cry1Ac + Cry1F + Vip3A)
FE	Enlist	2,4-D Tolerant**, Glyphosate Tolerant, Glufosinate Tolerant
T	TwinLink	Two-gene insect trait (Cry1Ac + Cry2Ae)
TP	TwinLink Plus	Three-gene insect trait (Cry1Ac + Cry2Ae + Vip3A)
GL	Glytol Liberty Link	Glyphosate Tolerant, Glufosinate Tolerant
B2	Bollgard II	Two-gene insect trait (Cry1Ac + Cry2Ab)
B3	Bollgard III	Three-gene insect trait (Cry1Ac + Cry2Ab + Vip3A)
RF	Roundup Ready Flex	Glyphosate Tolerant
XF	XtendFlex	Dicamba Tolerant**, Glyphosate Tolerant, Glufosinate Tolerant

*This table is only meant to serve as a guide to help determine traits associated with particular varieties, in all cases contact industry representatives for more information and details on managing cotton with these traits.

**Contact Industry Representative for specific recommendations on herbicides and traits.

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 On-Farm 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 valuable and easy tool for growers to use to compare performance of most modern varieties across Georgia. Small-plot UGA Official Variety Trial (OVT) data is also available at www.ugacotton.com as well as http://www.swvt.uga.edu/, and this data is also found in the UGA Cotton Variety Performance Calculator located at www.ugacotton.com. 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 performance across similar environments may be much less, which may be an indicator of inconsistency or poor stability. Varieties that perform well across a wide range of environments indicate a high degree of stability, which in turn suggests that these varieties may result in good performance across planting dates, soil types, rainfall patterns and irrigation practices, grower management practices, and other factors. Results from at least two years and several locations often provide a better indication of anticipated performance and stability. 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.

2016 UGA On-Farm Cotton Variety Performance Evaluation Program.
20 Locations (9 Irrigated, 11 Dryland)

Variety	Average Lint Yield (lb/A)	LSD Test Letters ($p<0.1$)			Frequency of Top Performance (% of 19 locations)				
		All 20 Locs.	8 Locs. < 1000 lb/A	12 Locs. > 1000 lb/A	Above Trial Average	Top 4	Top 3	Top 2	Top 1
PHY 444 WRF	1108	A	A	A	90	75	55	50	35
DG 2615 B2RF	1088	AB	ABCD	A	60	45	45	40	25
PHY 496 W3RF	1068	ABC	AB	AB	75	55	40	15	10
CG 3885 B2XF	1064	BC	ABC	AB	70	45	35	35	5
DP 1646 B2XF	1048	BCD	BCDE	AB	55	25	15	10	10
DP 1538 B2XF	1046	CD	BCDE	ABC	60	30	25	15	0
ST 6182 GLT	1030	CDE	BCDE	BC	55	20	0	0	0
NG 5007 B2XF	1029	CDE	CDE	BC	55	25	15	0	0
ST 5115 GLT	1015	DEF	BCD	CDE	45	30	25	0	0
PHY 333 WRF	991	EFG	CDE	DE	30	20	15	10	5
BX 1739 GLT	986	FG	F	BCD	30	15	15	15	5
NG 3522 B2XF	978	FG	DE	DE	30	5	5	5	0
DP 1553 B2XF	976	FG	DE	E	20	10	10	5	5
DG 3526 B2XF	971	G	EF	DE	15	0	0	0	0

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° 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. For optimal emergence, soil temperatures should be 65° 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° 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° 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.

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) and proper management 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 shorter season varieties. Thus, planting a major portion of ones crop in this way is not advised. The adoption of on-board module building pickers may allow growers to harvest peanuts and cotton simulateously, to the mutual benefit of both crops.

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. Seasonlong weather--particularly rainfall--continues to be the single greatest factor influencing yield.

Double Crop or Late-Planted Cotton

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 generally 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 ensure a vigorous stand, rapid stand establishment, and boll retention 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. Management (PGRs, Fertility, Irrigation etc) for a shorter season crop to maximize boll set and retention during the first 3 to 4 weeks of bloom.
3. Plant only 2 to 3 good quality seed/ft of row to alleviate the complications of late plantings and dense stands.
   SEE SECTION ON PLANT POPULATIONS / SEEDING RATES
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° 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 °F minus 60° F. The formula

is as follows:

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

For example, a day with a maximum of 86° F and a minimum temperature of 70° F produces 18 DD-60s, [(86 + 70 / 2) - 60 = (156/ 2) - 60 = 78 - 60 = 18 DD-60's]. Temperatures above 93° F should be entered in the formula at only 93° 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 at the UGA Cotton Webpage.

		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 effect 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.

Certain varieties have a tendency towards high mic, although the environment has the greatest influence on the final outcome and mic value. 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 POPULATIONS / SEEDING RATES

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) depending on soil-type. Increase planting rate if seed quality is poor or in fields in which seedling diseases, soil crusting, or otherwise poor emergence are expected to be 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 expensive 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.

Recent work has demonstrated that producers should aim for plant populations of at least 1.5 to 1.75 plants per row-foot to achieve maximum yields. This work, conducted during 2013 to 2016, examined seeding rates and plant populations in current production systems and varieties in high yield situations. Therefore, to ensure maximize yields with regards to seeding rates, producers should consider appropriate seeding rates to ultimately end up with the above mentioned 1.5 to 1.75 plants per row-foot. This presents a situation where producers should consider what practices and environmental circumstances impact germination and viability. Many things may impact results and in order to reach these stands, a seeding rate of at least 2 seed per row-foot is needed, and often much higher. Futher work is being conducted to more adequately examine germination and viability in production systems and therefore more information will be coming soon.

One question often asked when considering seeding rates and plant populations is "should I plant with a hill-drop plate or plant seed evenly apart with one seed per hill". A couple of things to consider when making this decision. First, research has shown that when the same populations are achieved in both situations there is not statistical differnce in yield. For example a seeding rate of 30,000 seed per acre planted with seed evenly spaced apart and in two seed hills should yield similarly. The trick

is what germination is achieved with the two systems. Hill-drop seeding may increase germination and ultimately impact yield from a standpoint of higher plant population than what would have emerged with single seed planting. Therefore, if hill-dropping seed helps with emergence, then it would likely be the better choice, if no advantage is provided with hill-dropping seed then either system would be appropriate.

One additional factor in regard to seeding rates and maximizing yield is planting date. Research has indicated that later planting dates may require higher populations in order to maximize yields. From a practical standpoint, producers planting cotton in June, where they intend to maximize yields (irrigation, etc.), should plant higher seeding rates than those previously mentioned and should aim for a final stand of 2 plants per row foot.

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. Planter adjustments may need to be made on a field-by-field basis to ensure optimal soil-to-seed contact.

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 especially 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 have the opportuntiy 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. Scouting and the use of thresholds, 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.

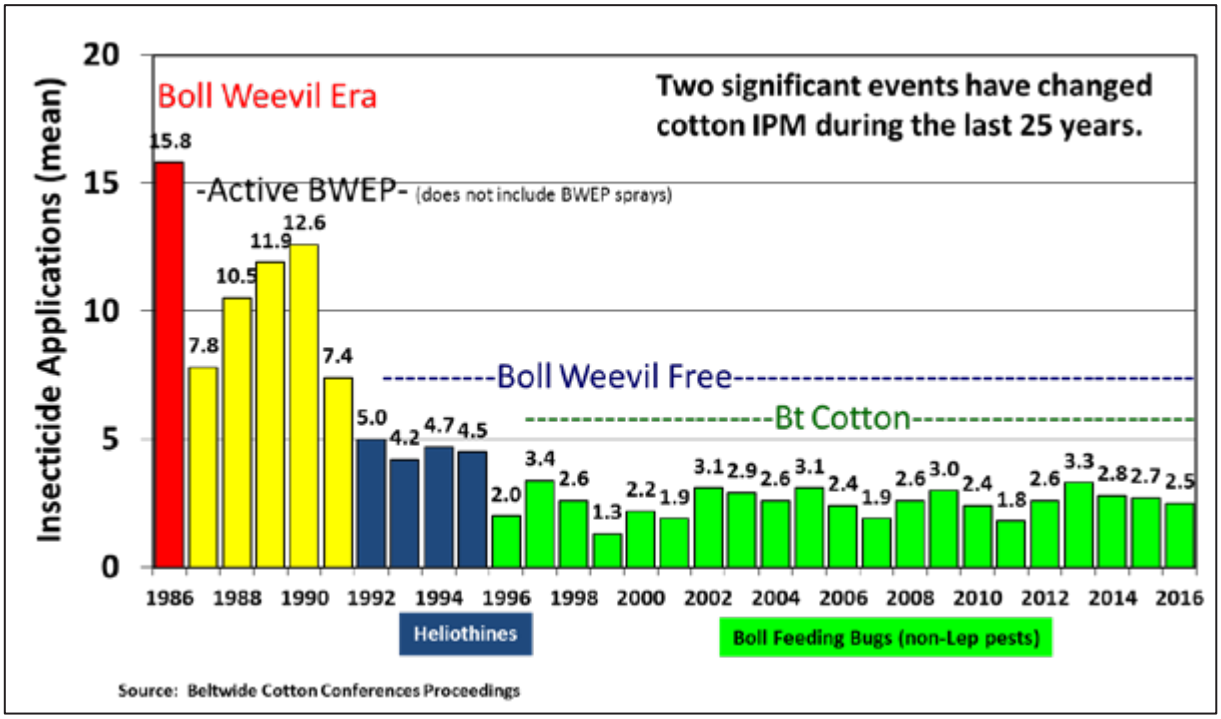


Figure 1. Mean insecticide applications applied on Georgia cotton, 1986-2015. The Boll weevil Eradication Program was initiated during the fall of 1986, insecticide applications applied by BWEP personel are not included in the mean insecticide applications.

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 the Cotton Insect Control tables below for insecticides, rates, and thresholds).

Beneficial Insects

Several 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 considered especially during early season. Big-eyed bugs, minute pirate bugs, fire ants, and *Cotesia* wasps are four important beneficial insects. The presence of these natural controls may delay the need to treat for some insect pests. The use of natural controls 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 the Cotton Insect Control tables below 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.

GA Cotton Insect Advisor App

GA Cotton Insect Advisor is an application system for determining Extension prescribed insecticide treatments for management of cotton insect pests in the state of Georgia. The app will display the most appropriate insecticide or tankmix after the user provides the appropriate week of bloom, predominant stink bug species, percent internal boll injury, and other pest species present. At present time, the app is intended for management of stink bugs only. Recommendations are based on information on the manufacturer's label and performance data from research and extension trials at the University of Georgia. GA Cotton Insect Advisor was developed by the University of Georgia Center for Invasive Species and Ecosystem Health in cooperation with the Department of Entomology with support from Cotton Incorporated.

The app insecticide or tankmix after the user provides the appropriate week of bloom, predominant stink bug species, percent the risk of flaring secondary insect pests which may be present but below established economic thresholds.

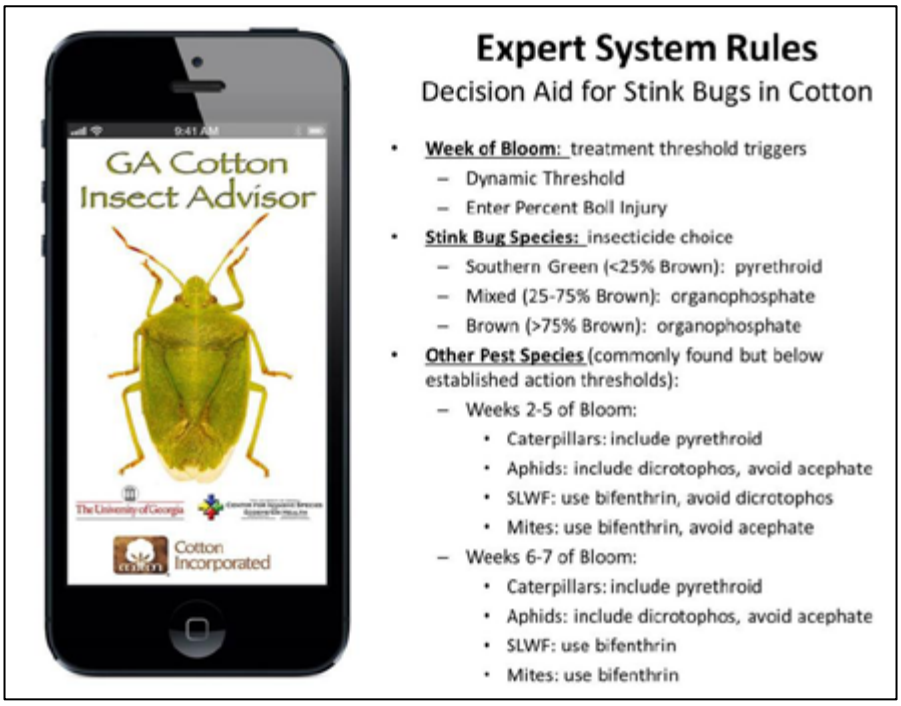


Figure 2. GA Cotton Insect Advisor App decision rules for insecticide selection.

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 the neonicotinoid seed treatments imidacloprid (Gaucho, and Aeris Seed Applied System) and thiamethoxam (Cruiser and Avicta Complete Cotton). Infurrow liquid applications of imidacloprid or acephate at planting are also options for early season control of thrips. Aldicarb (AgLogic 15G) was available on a limited basis during 2016. Very good thrips control was observed on farm and in small plot research trials conducted in 2016.

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 (i.e. PRE herbicide injury).
- 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.

Neonicotinoid seed treatments including imidacloprid or thiamethoxam provide similar levels of thrips control and are active on thrips for 14-21 days after planting. Research and observation have shown that a supplemental foliar spray is often needed in addition to a neonicotinoid seed treatment

when thrips infestations are high. We typically expect to see higher thrips infestations on early planted cotton in conventional tillage systems. Unless thorough scouting reveals thrips populations are below established thresholds, **a foliar thrips systemic insecticide should be applied at the 1-leaf stage in conventional tilled fields planted prior to May 10 when a noenicotinoid 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.

Thrips populations have shown reduced susceptibility to neonicotinoid (thiamethoxam and imidacloprid) seed treatments in Georgia, the southeast, and Mid-South. Thrips feeding and damage on seedlings treated with thiamethoxam appears to be more severe than on seedlings treated with imidacloprid. Although we are seeing reduced susceptibility, the neonicotinoid seed treatments remain beneficial and provide much needed protection during early growth stages when seedlings are most sensitive to yield loss from thrips. Both imidacloprid and acephate applied as as in-furrow liquid have provided improved control of thrips and longer residual when compared with seed treatments.

Acephate is an organophosphate and is an alternaive at plant thrips treatment to the neonicotinoids. Acephate can be applied as a seed treatment (has limited residual, about 7 days) or an in-furrow spray where control and residual is improved compred with acephate applied as a seed treatment. One negative when comparing Orthene to neonicotinoids is the lack of cotton aphid control when acephate is used. We rarely observe cotton aphids on seedling cotton due in part to the fact that neonicotinoids and aldicarb, which was the standard insecticide used for thrips control for many years, have activity on aphids.

Aphid Management

Cotton aphid is a fairly 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 levels 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 (TBW) and corn earworm (CEW) appear very similar in the egg and larval stages and cause similar damage. However, they are different insects and their susceptibility to specific insecticides differ. Three generations of TBW 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 CEW infest cotton. The first CEW 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 TBW and CEW 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. TBW and CEW larvae can be distinguished upon careful examination with a hand lens or use of a dissecting microscope (see ugacotton.com). Populations of TBW infesting Georgia cotton are resistant to the pyrethroid class of insecticides and therefore **non-pyrethroid insecticides should be used to control TBW**.

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 TBW and CEW is also important in Bt cotton. CEW is less susceptible to Bt toxins compared with TBW. Supplemental insecticide treatments may be needed for CEW control on Bt cotton whereas Bt cottons provide excellent control of TBW.

Pyrethroid Resistant Tobacco Budworm

TBW 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 TBW. In areas where TBW 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 TBW. Non-pyrethroid insecticides should be used in a timely basis for control of TBW on non-Bt cotton.

Corn Earworm and Reduced Pyrethroid Susceptibility

Susceptibility of CEW to pyrethroid insecticides has declined and become more erratic in some areas of the US during recent years. We suspect changes are occurring in Georgia, but have not experienced field control problems in recent years which may be due to low CEW infestations in cotton; actually few pyrethroids have targeted CEW for control in any crop. Dr. Greg Payne, University of West Georgia, annually collects CEW and TBW and conducts indepth assays on CEW susceptibility to pyrethroids, spinosad, and Bt. These assays take time and typically results are not known for several months. To compliment these efforts, we also monitor susceptibility of CEW to pyrethroids using an Adult Vial Test (AVT) which has a quick turnaround time. To conduct Adult Vial Tests, moths are collected from pheromone traps and placed in pyrethroid treated vials (cypermethrin 5 µg/vial) and mortality is evaluated 24 hours later. Figure 3 illustrates the seasonal mean survival of CEW in AVTs conducted from 2006-2016. We observed high survival during the last three years, especially during 2016. Note that survival during 2007 was also high and in that year we did experience some issues with control of CEW with pyrethroids in the field. Survival we observed in recent years is similar to that observed in areas where field control problems are occurring. Increased survival suggests that populations will be more difficult to control with a field application of a pyrethroid insecticide.

Current recommendations for control of corn earworm include the use of high rates of pyrethroids. 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, and 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. Results of Adult Vial Tests will be reported on ugacotton.com as needed during the growing season as well as reports of field control problems and any changes to current recommendations.

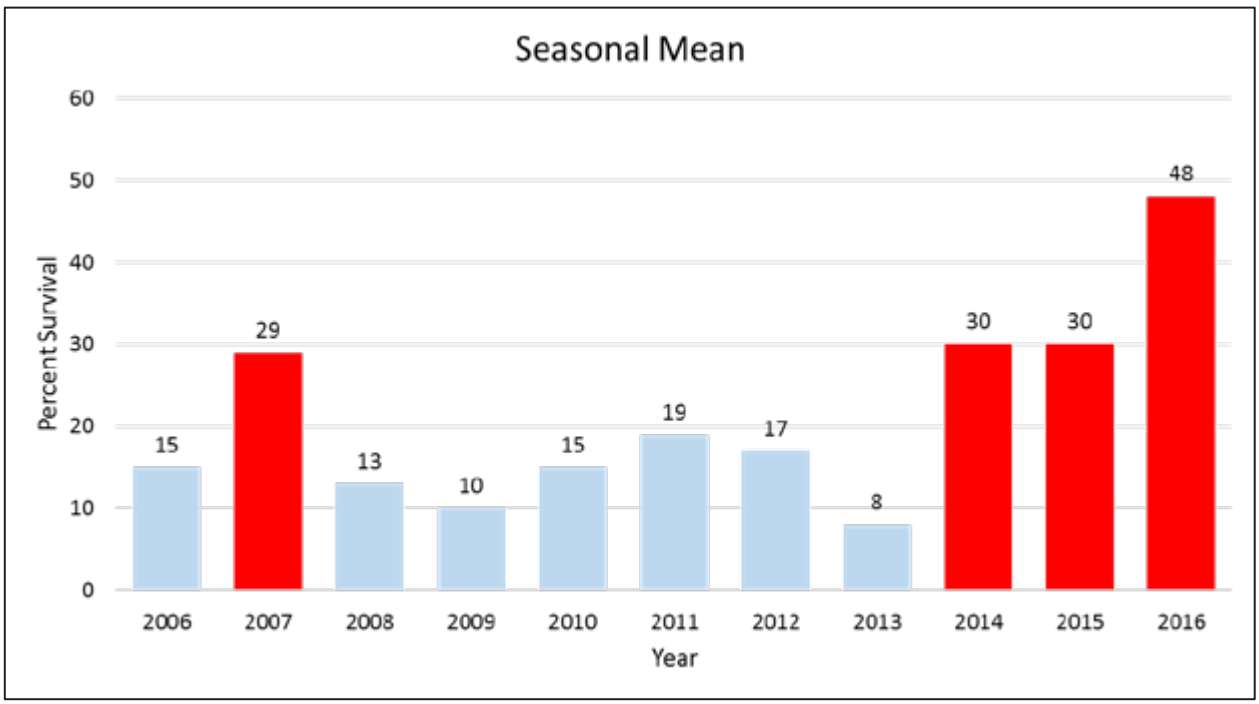


Figure 3. Seasonal mean survival of CEW in Adult Vial Tests (cypermethrin 5 mg/Mean insecticide applications applied on Georgia cotton, 1986-2015. The Boll weevil Eradication Program was initiated during the fall of 1986, insecticide applications applied by BWEP personel are not included in the mean insecticide applications.

Bt Cotton Management

Commercially available Bt cotton technologies include Bollgard II, WideStrike, TwinLink, WideStrike III, and TwinLink Plus. **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.

Currently available Bt cottons 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 and fall and beet armyworms. 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 crops provide continuous season long activity against target pests, 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. Bt cotton was first commercialized in 1996. Since that time additional Bt genes have been stacked (2-3 Bt genes) in Bt cottons for improved performance and resistance management benefits. In addition to cotton, a significant percentage of corn contains Bt genes. Resistance management is required when planting Bt cotton or Bt corn. These resistance management plans are designed to delay and hopefully prevent the development of resistance. Bt genes in cotton and corn are similar and it is imperative that resistance management plans are followed in both crops to preserve the Bt technology. Bt corn utilizes a structured refuge where a percentage of non-Bt corn must be planted. Resistance management in Bt cotton uses a natural refuge (weedy host plants and non-cotton agronomic crops). Producers should maintain full knowledge of the details and follow resistance management requirements of use agreements with suppliers of transgenic seed or technology.

Corn Earworm Susceptibility to Bt Cotton

Bt cotton is not and has never been immune to CEW. Since commercialization of Bt cotton, a percentage of Bt cotton grown in Georgia has required supplemental treatment of CEW in most years. There is variability in performance of the various Bt cottons. In recent years it appears susceptibility of CEW to Bt cotton has declined in parts of the US. Only a small percentage of Bt cotton has required supplemental treatment for CEW in Georgia during recent years so we have not observed this decline in efficacy in the field. However, researchers have seen reduced efficacy in Bt corn in Georgia and other areas of the southeast. Bt cotton must be scouted on a regular basis and growers must be prepared to act accorndingly if thresholds are exceeded.

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.

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

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.

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.

Terminating Insecticide Applications

The decision to terminate insect controls can be challenging in some fields but a few basic considerations will assist in that decision. When evaluating a field a grower must first identify the last boll population which will significantly contribute to yield (bolls which you plan to harvest). In some situations the last population of bolls which you will harvest is easy to see (i.e. cotton which is loaded and cutout). In others, such as late planted cotton, the last population of bolls you will harvest will be determined by weather factors (the last bloom you expect to open and harvest based on heat unit accumulation). Once the last boll population is determined the boll development or approximate boll age should be estimated. Depending on the insect pest, bolls are relatively safe from attack at varying stages of boll development.

Insect Pest(s)	**Approx. Boll Age (days)**
Corn Earworm Tobacco Budworm	18-20 bolls fully sized
Stink Bugs	25
Fall Armyworm	bolls near maturity
Foliage Feeders soybean looper beet armyworm southern armyworm	bolls mature
Sucking Insects whiteflies aphids	harvest (honeydew accumulation on lint)

The table below list approximate boll age in days which bolls should be protected for selected insect pests. Cooler temperatures will slow plant development and subsequent boll age values may increase in such environments. It is assumed that the field is relatively insect pest free when the decision to terminate insecticide applications for a pest is made.

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.

COTTON INSECT CONTROL

Phillip M. Roberts, Extension Entomologist and Mike Toews, Research Entomologist

PEST	INSECTICIDE	MOA	FORMULATION PER ACRE	LBS. ACTIVE PER ACRE	REI/PHI (Hours or Days)	REMARKS
Aphid (Cotton)	*acetamiprid* Assail 30SG	4A	1.5-2.5 oz	0.028-0.047	12 H/ 28 D	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 Dicromax 8	1B	4-8 oz 4-8 oz	0.25-0.50 0.25-0.5	6 D/ 30 D	
	flonicamid Carbine 50WG	9C	1.4-2.8 oz	0.044-0.088	12 H/ 30 D	
	imidacloprid Admire Pro 4.6	4A	0.9-1.7 oz	0.032-0.061	12 H/ 14 D	
	thiamethoxam Centric 40 WG	4A	1.25-2.0 oz	0.031-0.05	12 H/ 21 D	
Beet Armyworm	*emamectin benzoate* Denim 0.16	6	6-8 oz	0.0075-0.01	12 H/ 21 D	Apply when 10% of squares or terminals are damaged, 10% of blooms are damaged and/or infested, or when 10 active "hits" are observed per 300 row feet. Beet armyworms may infest Palmer amaranth and move to cotton as larvae develop. Bt cottons will not control large beet armyworms moving from Palmer amaranth.
	diflubenzuron Dimilin 2L	15	4-8 oz	0.0625-0.125	12 H/ 14 D	
	indoxacarb Steward 1.25EC	22	9.2-11.3 oz	0.09-0.11	12 H/ 14 D	
	methoxyfenozide Intrepid 2F	18	4 oz	0.0625	4 H/ 14 D	
	novaluron Diamond 0.83EC	15	6-12 oz	0.039-0.077	12 H/ 30 D	
	chlorantraniliprole Prevathon 0.43	28	14-27 oz	0.047-0.09	4 H/ 21 D	
	spinosad Blackhawk	5	2.4-3.2 oz	0.054-0.072	4 H/ 28 D	
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, TwinLink, or WideStrike Bt genes are effective tools for use in bollworm and tobacco budworm management programs. Apply insecticide on Bt cotton when 8 larvae (1/4 " or greater in length) are found per 100 plants.
	emamectin benzoate Denim 0.16	6	8-12 oz	0.01-0.015	12 H/ 21 D	
	indoxacarb Steward 1.25EC	22	11.3 oz	0.11	12 H/ 14 D	
	methomyl Lannate LV 2.4	1A	1.5-2 pt	0.45-0.6	72 H/ 15 D	
	profenofos Curacron 8E	1B	0.75-1 pt	0.75-1.0	48 H/ 30 D	
	spinetoram Radiant 1 SC	5	4.25-8.0 oz	0.0332-0.0625	4 H/ 28 D	

PEST	INSECTICIDE	MOA	FORMULATION PER ACRE	LBS. ACTIVE PER ACRE	REI/PHI (Hours or Days)	REMARKS
Bollworm/ Tobacco Budworm (continued)	**NON-PYRETHROIDS**					
	chlorantraniliprole Prevathon 0.43	28	14-27 oz	0.047-0.09	4 H/ 21 D	
	spinosad Blackhawk	5	2.4-3.2 oz	0.054-0.072	4 H/ 28 D	
	PYRETHROIDS					Tobacco budworm is resistant to pyrethroid insecticides. Pyrethroids should not be used for control of tobacco budworm.
	alpha-cypermethrin Fastac 0.83	3A	2.6-3.6 oz	0.017-0.023	12 H/ 14 D	
	beta-cyfluthrin Baythroid XL 1	3A	1.6-2.6 oz	0.0125-0.02	12 H/ 0 D	
	bifenthrin Brigade 2EC Discipline 2EC Fanfare 2EC	3A	 2.6-6.4 oz 2.6-6.4 oz 2.6-6.4 oz	 0.04-0.1 0.04-0.1 0.04-0.1	12 H/ 14 D	
	cypermethrin Up-Cyde 2.5EC	3A	2-5 oz	0.04-0.1	12 H/ 14 D	
	esfenvalerate Asana XL 0.66	3A	5.8-9.6 oz	0.03-0.0495	12 H/ 21 D	
	gamma-cyhalothrin Prolex 1.25 Declare 1.25	3A	 1.28-2.05 oz 1.28-2.05 oz	 0.0125-0.02 0.0125-0.02	24 H/ 21 D	
	lambda-cyhalothrin Warrior II Zeon 2.08 Silencer 1	3A	 1.6-2.56 oz 3.2-5.12 oz	 0.025-0.04 0.025-0.04	24 H/ 21 D	
	zeta-cypermethrin Mustang Max 0.8	3A	2.64-3.6 oz	0.0165-0.0225	12 H/ 14 D	
Bollworm/Tobacco Budworm (ovicides)	*methomyl* Lannate LV 2.4	1A	0.4-0.75 pt	0.12-0.22	72 H/ 15 D	Apply in a tank-mix with a larvacide when large numbers of eggs are present.
	profenofos Curacron 8E	1B	0.125-0.25 pt	0.125-0.25	48 H/ 30 D	
Cutworm (seedling cotton)	*acephate* Orthene 97 Acephate 97	1B	 0.75 lb 0.75 lb	 0.72 0.72	24 H/ 21 D	Apply when stand is threatened. Spot treatment is often adequate. Pyrethroids provide good control of cutworms at low rates. See insecticide label for use rate.
	chlorpyrifos Lorsban 4E Chlorpyrifos 4E	1B	 1.5-2 pt 1.5-2 pt	 0.75-1 0.75-1	24 H/ 14 D	
	Pyrethroids	3A	See Remarks			

PEST	INSECTICIDE	MOA	FORMULATION PER ACRE	LBS. ACTIVE PER ACRE	REI/PHI (Hours or Days)	REMARKS
Fall Armyworm	*chlorantraniliprole* Prevathon 0.43	28	14-27 oz	0.047-0.09	4 H/ 21 D	Apply when 15 larvae are found per 100 plants. Control of large larvae (›1/2" in length) is difficult; higher rates should be used.
	diflubenzuron Dimilin 2L	15	4-8 oz	0.0625-0.125	12 H/ 14 D	
	emamectin benzoate Denim 0.16	6	8-12 oz	0.01-0.015	12 H/ 21 D	
	indoxacarb Steward 1.25EC	22	9.2-11.3 oz	0.09-0.11	12 H/ 14 D	
	methomyl Lannate LV 2.4	1A	1.5-2 pt	0.45-0.6	72 H/ 15 D	
	methoxyfenozide Intrepid 2F	18	4-10 oz	0.0625-0.156	4 H/ 14 D	
	novaluron Diamond 0.83EC	15	6-12 oz	0.039-0.077	12 H/ 30 D	
	profenofos Curacron 8E	1B	0.75-1 pt	0.75-1	48 H/ 30 D	
	Pyrethroid	3A	See Remarks			Pyrethroids at high rates provide good suppression of larvae less than 1/8" in length.
	spinosad Blackhawk	5	2.4-3.2 oz	0.054-0.072	4 H/ 28 D	
Plant Bugs and Fleahoppers	*acephate* Orthene 97 Acephate 97	1B	0.25-0.50 lb 0.25-0.50 lb	0.24-0.49 0.24-0.49	24 H/ 21 D	Apply insecticide when plants are retaining less than 80% of pinhead squares and numerous plant bugs are observed. Sweep nets and drop cloths may also be used to monitor plant bugs. Sweep nets (15" in diameter) are an effective tool for monitoring adult plant bug populations. Drop cloths are more effective for monitoring immatures. Thresholds: First 2 weeks of squaring: Sweep Net: 8 plant bugs/100 sweeps. Drop Cloth: 1 plant bug/6 row feet. Third week of squaring through bloom: Sweep Net: 15 plant bugs/100 sweeps. Drop Cloth: 3 plant bug/6 row feet. Diamond is an insect-growth regulator and will not control adults.
	dicrotophos Bidrin 8 Dicromax 8	1B	4-8 oz 4-8 oz	0.25-0.5 0.25-0.5	6 D/ 30 D	
	imidacloprid Admire Pro 4.6	4A	0.9-1.7 oz	0.032-0.061	12 H/ 14 D	
	novaluron Diamond 0.83EC	15	9-12 oz	0.058-0.077	12 H/ 30 D	
	oxamyl Vydate C-LV 3.77	1A	8.5-17 oz	0.25-0.50	48 H/ 14 D	
	thiamethoxam Centric 40 WG	4A	2 oz	0.05	12 H/ 21 D	

PEST	INSECTICIDE	MOA	FORMULATION PER ACRE	LBS. ACTIVE PER ACRE	REI/PHI (Hours or Days)	REMARKS
Soybean Looper	*emamectin benzoate* Denim 0.16	6	8-12 oz	0.01-0.015	12 H/ 21 D	Treatment is necessary when soybean loopers threaten to defoliate cotton with immature bolls.
	indoxacarb Steward 1.25EC	22	6.7-9.2 oz	0.065-0.09	12 H/ 14 D	
	methoxyfenozide Intrepid 2F	18	4-10 oz	0.0625-0.156	4 H/ 14 D	
	novaluron Diamond 0.83EC	15	6-12 oz	0.039-0.077	12 H/ 30 D	
	spinosad Blackhawk	5	2.4-3.2 oz	0.052-0.072	4 H/ 28 D	
Spider Mites	*abamectin* Agri-Mek 0.15	6	8-16 oz	0.009-0.018	12 H/ 20 D	Apply when 50 percent of plants are symptomatic and populations are increasing. Spot treatment may be adequate. Thoroughcoverage is essential; a second application may be necessary. In fields where mites are observed, conservation of beneficial insects should be a priority; insecticides prone to flare mites should be avoided when targeting other pests. *Bifenthrin may provide suppression of mites.
	etoxazole Zeal 72 WSP	10B	0.66-1 oz	0.03-0.045	12 H/ 28 D	
	fepyroximate Portal 0.4	21A	16-32 oz	0.05-0.1	12 H/ 14 D	
	propargite Comite II 6	12C	1.25-2.25 pt	0.937-1.687	6 D/ 50 D	
	profenofos Curacron 8E	1B	0.5-0.75 pt	0.5-0.75	48 H/ 30 D	
	spiromesifen Oberon 2SC	23	8-16 oz	0.125-0.25	12 H/ 30 D	
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/6 row feet would also justify treatment. Higher stink bug populations are typically observed on late-planted cotton compared with early-planted cotton. Organophosphates should be used for control of brown stink bugs.
	acephate Orthene 97 Acephate 97	1B	0.75 lb 0.75 lb	0.72 0.72	24 H/ 21 D	
	dicrotophos Bidrin 8 Dicromax 8	1B	4-8 oz 4-8 oz	0.25-0.5 0.25-0.5	6 D/ 30 D	

PEST	INSECTICIDE	MOA	FORMULATION PER ACRE	LBS. ACTIVE PER ACRE	REI/PHI (Hours or Days)	REMARKS
Stink Bugs (continued)	**PYRETHROIDS**					
	alpha-cypermethrin Fastac 0.83	3A	2.6-3.6 oz	0.017-0.023	12 H/ 14 D	
	beta-cyfluthrin Baythroid XL 1	3A	1.6-2.6 oz	0.0125-0.0205	12 H/ 0 D	
	bifenthrin Brigade 2EC Discipline 2EC Fanfare 2EC	3A	 2.6-6.4 oz 2.6-6.4 oz 2.6-6.4 oz	 0.04-0.1 0.04-0.1 0.04-0.1	12 H/ 14 D	
	esfenvalerate Asana XL 0.66	3A	5.8-9.6 oz	0.03-0.0495	12 H/ 21 D	
	gamma-cyhalothrin Prolex 1.25 Declare 1.25	3A	 1.28-2.05 oz 1.28-2.05 oz	 0.0125-0.02 0.0125-0.02	24 H/ 21 D	
	lambda-cyhalothrin WarriorII Zeon 2.08 Silencer 1	3A	 1.6-2.56 oz 3.2-5.12 oz	 0.025-0.04 0.025-0.04	24 H/ 21 D	
	zeta-cypermethrin Mustang Max 0.8	3A	2.64-3.6 oz	0.0165-0.0225	12 H/ 14 D	
Thrips (seedling cotton), At-Plant Treatments	*acephate* Orthene 97ST Orthene 97 Acephate 97	1B	 Commercial Seed Treatment 1 lb 1 lb	 0.97 0.97	24 H/ 21 D	Apply acephate as a spray into the seed furrow at planting.
	imidacloprid Admire Pro4.6	4A	 9.2 oz	 0.33	12 H/ 14 D	Apply Admire Pro as an in-furrow spray during planting directed on or below seed.
	thiamethoxam Cruiser	4A	Commercial Seed Treatment		12 H/ --	Thrips populations in some areas of the US have shown reduced susceptibility to neonicotinoid seed treatments (IRAC Group 4A). Neonicotinoid seed treatments are active for 14-21 days but may need a supplemental foliar insecticide application if thrips populations are high.
	imidacloprid Gaucho 600	4A	Commercial Seed Treatment		12 H/ --	
Thrips (seedling cotton), Foliar Spray	*acephate* Orthene 97 Acephate 97	1B	 3 oz 3 oz	 0.18 0.18	24 H/ 21 D	Apply when 2-3 thrips per plant are counted and immatures are present. Expect higher thrips populations on early planted cotton. Seedlings are most susceptible to thrips during early growth stages; economic damage rarely occurs once seedlings reach the 4-leaf stage and are growing rapidly. Thrips injury is more severe when seedlings are not growing rapidly (i.e. stress from cool temperatures or PRE herbicides). Rapidly growing seedlings can better tolerate thrips feeding.
	dicrotophos Bidrin 8 Dicromax 8	1B	 1.6-3.2 oz 1.6-3.2 oz	 0.1-0.2 0.1-0.2	6 D/ 30 D	

PEST	INSECTICIDE	MOA	FORMULATION PER ACRE	LBS. ACTIVE PER ACRE	REI/PHI (Hours or Days)	REMARKS
Thrips (seedling cotton), Foliar Spray (continued)	*dimethoate* Dimethoate 4	1B	0.25-0.5 pt	0.125-0.25	48 H/ 14 D	
Whitefly (banded winged)	*acephate* Orthene 97 Acephate 97	1B	0.5-1 lb 0.5-1 lb	0.49-0.97 0.49-0.97	24 H/ 21 D	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.
	thiamethoxam Centric 40 WG	4A	2 ozs	0.05	12 H/ 21 D	
Whitefly (silverleaf)	*acetamiprid* Assail 30 SG	4A	4-5.3 oz	0.075-0.1	12 H/ 28 D	Apply when 50 percent of sampled leaves (sample 5th expanded leaf below the terminal) are infested with multiple immatures. 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.
	dinotefuron Venom 70WDG	4A	1-3 oz	0.045-0.134	12 H/ 14 D	
	flupyradifurone Sivanto Prime 1.67	4D	10.5-14 oz	0.1369-0.1826	4H/ 14D	
	pyriproxyfen Knack 0.86	7C	8 oz 5 oz fb 5 oz	0.05375 0.033 fb 0.033	12 H/ 28 D	Vegetative cotton; 5 oz followed by 5 oz. See Label.
	spiromesifin Oberon 2	23	8-16 oz	0.125-0.25	12 H/ 30 D	
	buprofezin Courier 3.6 SC	16	9-12.5 oz	0.25-0.35	12 H/ 14 D	

Premixed or Co-Packed 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 of reduced rates of an active ingredient may lead to or intensify insecticide resistance.

bifenthrin, avermectin B1 (Athena) *bifenthrin, imidacloprid* (Brigadier) *dicrotophos, bifenthrin* (Bidrin XP II) *methoxyfenozide,spinetoram* (Intrepid Edge)
imidacloprid, cyfluthrin (Leverage)
lambda-cyhalothrin, chlorantraniliprole (Besiege) *lambda-cyhalothrin, thiamethoxam* (Endigo) *spinosad, gamma-cyhalothrin* (Consero)
zeta-cypermethrin, bifenthrin (Hero)
chlorpyrifos, lambda-cyhalothrin (Cobalt Advanced) *zeta-cypermethrin, chlorpyrifos* (Stallion) *chlorpyrifos, bifenthrin* (Tundra Supreme)
fluppyram, imidacloprid (Velum Total)

INSECT PEST RESPONSE TO INSECTICIDES USED IN COTTON

INSECTICIDE	SOUTHERN GREEN STINK BUG	BROWN STINK BUG	CORN EARWORM	TOBACCO BUDWORM**	FALL ARMYWORM	BEET ARMYWORM	SOYBEAN LOOPER	PLANT BUGS	APHIDS	SPIDER MITES	SILVERLEAF WHITEFLY	CUTWORMS	THRIPS	PREDATORS***	PARASITES***	CHEMICAL CLASS (MOA)	REI (Hours)*
abamectin Agri-Mek 0.15	-	-	-	-	-	-	-	-	-	1	-	-	-	M	M	6	12
acephate Orthene 97	2	2	5	4	4	5	4	1	5	5	5	2	1	H	H	1B	24
acetamiprid Assail 30SG	4	4	5	5	5	5	5	3	1	5	1	5	3	E	E	4A	12
alpha-cypermethrin Fastac 0.83	2	4	1	3	4	5	4	3	4	5	5	2	4	H	M	3A	12
beta-cyfluthrin Baythroid XL 1	1	3	1	3	3	5	4	2	4	5	5	2	4	H	M	3A	12
bifenthrin Brigade 2, Discipline 2, Fanfare 2	1	2	1	3	3	5	4	2	3	3	3	2	4	H	M	3A	12
buprofezin Courier 40 SC	-	-	-	-	-	-	-	-	-	-	1	-	-	E	E	16	12
chlorantraniliprole Prevathon 0.43	5	5	1	1	2	1	2	5	5	5	4	4	5	E	E	28	4
chlorpyirifos Lorsban 4	4	4	4	4	3	3	4	3	4	3	5	1	3	H	H	1B	24
cypermethrin Up-Cyde 2.5EC	2	4	1	3	4	5	4	3	4	5	5	2	4	H	M	3A	12
dicrotophos Bidrin 8	1	1	5	5	5	5	5	1	3	4	5	5	1	H	H	1B	6 days

Efficacy Ratings:
1 = Very Effective
5 = Not Effective

* Read and follow label directions.
** Pyrethroid resistant tobacco budworm have been observed in Georgia, efficacy may be improved if resistance levels are low.
*** Effects on beneficial insects: E = Easy; M = Moderate; and H = Hard

Effects of some insecticides are highly rate sensitive.

Insecticide ratings found in this table are based on research across the Cotton Belt and on field experiences and observations by entomologists. Ratings assume standard rates of insecticides applied at proper times. Ratings should be considered only as general guidelines for comparison purposes.

INSECTICIDE	SOUTHERN GREEN STINK BUG	BROWN STINK BUG	CORN EARWORM	TOBACCO BUDWORM**	FALL ARMYWORM	BEET ARMYWORM	SOYBEAN LOOPER	PLANT BUGS	APHIDS	SPIDER MITES	SILVERLEAF WHITEFLY	CUTWORMS	THRIPS	PREDATORS***	PARASITES***	CHEMICAL CLASS (MOA)	REI (Hours)*
diflubenzuron Dimilin 2L	5	5	5	5	3	3	4	5	5	5	5	5	5	E	E	15	12
dimethoate Dimethoate 4	4	4	5	5	5	5	5	3	3	3	5	5	2	M	H	1B	48
dinotefuron Venom 70 WDG	-	-	-	-	-	-	-	-	-	-	2	-	-	M	M	4A	12
emamectin benzoate Denim 0.16	4	4	2	2	2	1	1	4	5	3	5	4	4	M	E	6	12
esfenvalerate Asana XL 0.66	2	4	1	3	4	5	4	3	4	5	5	2	4	H	M	3A	12
etoxazole Zeal 72 WSP	-	-	-	-	-	-	-	-	-	-	1	-	-	E	E	10B	12
fepyroximate Portal 0.4	-	-	-	-	-	-	-	-	-	1	3	-	-	E	E	21A	12
flonicamid Carbine 50 WG	4	4	5	5	5	5	5	2	1	5	5	5	3	E	E	9C	12
gamma-cyhalothrin Declare 1.25, Prolex 1.25	1	3	1	3	3	5	4	2	4	5	5	2	4	H	M	3A	24
imidacloprid Admire Pro 4.6	4	4	5	5	5	5	5	3	2	5	4	5	3	M	M	4A	12
indoxacarb Steward 1.25	4	4	2	1	2	1	1	3	5	5	5	4	5	M	E	22A	12
lambda-cyhalothrin Warrior II Z 2.08, Silencer 1	1	3	1	3	3	5	4	2	4	5	5	2	4	H	M	3A	24

Efficacy Ratings:
1 = Very Effective
5 = Not Effective

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INSECTICIDE	SOUTHERN GREEN STINK BUG	BROWN STINK BUG	CORN EARWORM	TOBACCO BUDWORM**	FALL ARMYWORM	BEET ARMYWORM	SOYBEAN LOOPER	PLANT BUGS	APHIDS	SPIDER MITES	SILVERLEAF WHITEFLY	CUTWORMS	THRIPS	PREDATORS***	PARASITES***	CHEMICAL CLASS (MOA)	REI (Hours)*
methomyl Lannate LV 2.4	4	4	3	3	3	4	3	3	4	5	5	3	5	H	M	1A	72
methoxyfenozide Intrepid 2F	5	5	4	4	2	1	2	5	5	5	5	4	5	E	E	18	4
novaluron Diamond 0.83EC	3	3	4	4	1	2	2	3	5	5	4	5	5	M	3	15	12
oxamyl Vydate C-LV 3.77	3	3	5	5	5	5	5	2	5	5	5	5	3	M	M	1A	48
profenofos Curacron 8E	4	4	3	3	3	4	4	3	4	3	5	3	4	H	H	1B	48
propargite Comite II 6	5	5	5	5	5	5	5	5	5	1	5	5	5	M	E	12C	6 days
pyriproxyfen Knack 0.86	5	5	5	5	5	5	5	5	5	5	1	5	5	E	E	7C	12
spinosad Blackhawk	5	5	2	1	2	2	2	5	5	5	5	4	4	E	M	5	4
spiromesifen Oberon 2 SC	-	-	-	-	-	-	-	-	-	1	2	-	-	E	E	23	12
thiamethoxam Centric 40 WG	3	4	5	5	5	5	5	1	1	5	3	5	3	M	M	4A	12
zeta-cypermetherin Mustang Max 0.8	1	3	1	3	3	5	4	2	4	5	5	2	4	H	M	3A	12

Efficacy Ratings:
1 = Very Effective
5 = Not Effective

* Read and follow label directions.
** Pyrethroid resistant tobacco budworm have been observed in Georgia, efficacy may be improved if resistance levels are low.
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COTTON DISEASE AND NEMATODE MANAGEMENT: 2017 Updates

SECTION 1. IMPORTANT MANAGEMENT STRATEGIES FOR THE 2017 GROWING SEASON:

The importance of diseases and nematodes in cotton production is easy to overlook since the cotton plant is often less severely affected by disease than are other crops and symptoms caused by nematodes can be easily misdiagnosed.

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 plant-parasitic nematodes and pathogens remains one of the most effective means of reducing losses in cotton. In the 2017 field season, growers need to carefully consider selecting cotton varieties with resistance to southern root-knot nematodes and bacterial blight; unfortunately our varieties are typically not resistant to both. Also, growers have an expanding arsenal of fungicides to choose from for management of target spot.

Important message for 2017: Bacterial blight has been of increasing concern to cotton growers in 2015 and 2016. In all likelihood, bacterial blight will also impact our cotton production in 2017. Through efforts of consultants and UGA Extension agents, bacterial blight was documented across much of our production area in 2016.

When it come to bacterial blight, please remember the following:

Losses to bacterial blight did occur in some fields. However, in other fields, bacterial blight could be found; however the damage was "cosmetic" with likely little, if any, losses. The two most important tactics to manage bacterial blight are 1) plant resistant varieties and 2) manage crop debris from the previous cotton crop by burying it or through crop rotation.

Listed in the initial section of this chapter are some of the most important disease and nematode considerations for producing cotton in the upcoming season. Each topic will be discussed in greater detail later in the chapter.

Management of southern root-knot nematodes: Consider planting resistant varieties, e.g., PHY 487 WRF, DP 1558NR B2RF and ST 4946 GLB2 where southern root-knot nematodes are a problem. Extra concern this year should be exercised in variety selection based upon need for root-knot nematode resistance and the importance of bacterial blight. For example, DP 1558NR B2RF has excellent resistance to southern root-knot nematodes, but was affected by bacterial blight in some, but certainly not all, fields in 2016. Recommendations for a variety such as DP 1558NR B2RF would depend on three questions. 1) Is your field affected by southern root-knot nematodes? 2) Was bacterial blight a problem in your fields in 2015 and/or 2016? 3) What is your tolerance for risk to bacterial blight? If you have not had bacterial blight and are not worried about a little "cosmetic" injury, then DP 1558 should be one of the root-knot nematode varieties you consider. If you had significant impact from bacterial blight in 2015 or 2016, or you simply find any level of bacterial blight unacceptable, even if it does not affect yield and the variety performs well with nematode resistance, then you may want to select a variety with great bacterial blight resistance and manage nematodes with another resistant variety or with nematicides.

Management of nematodes with Telone II: Fumigation with Telone II (3 gal/A) using "risk management of zones" and "site specific" applications to maximinze yields and minimize cost are important advances in management of nematodes affecting cotton. **NOTE:** The supply of Telone II

in 2017 will be restricted. Growers who would like to use Telone II in 2017 should contact their supplier immediately to begin plans for obtaining needed product.

Management of nematodes: In 2017, cotton growers in Georgia can also choose seed treatment nematicides, Velum Total and AgLogic15G for management of all parasitic nematodes affecting cotton. Such treatments are expected to provide positive economic returns (increased yield versus cost of application when nematode populations are at, or moderately above, economic threshold levels). **2016 was the first year that UGA Extension assessed Aglogic 15G in cotton and peanut research trials. Additional information will be available from your local UGA Extension agents.**

Fusarium wilt: This disease causes significant losses in some fields every year; management options include crop rotation and management of nematodes. But is this enough? From data collected in 2015 and 2016, it seems that many fields affected by Fusarium wilt are often infested with the Sting nematode. If fields affected by Fusarium wilt are infested with sting nematode, then planting root-knot nematode resistant varieties will not help to reduce impact of the diseease. Fields affected by Fusarium wilt did respond in 2016 to fumigation with Telone II and also, in at least one field, treatment with Velum Total. Both treatments improved yields in at least some fields.

Bacterial blight/angular leaf spot: This disease was more severe in 2015 in Georgia then it had been in many years and resulted in significant defoliation and boll rot in some fields. While the disease was most severe in DPL 1454 B2RF, bacterial blight was found in other varieties as well. Bacterial blight could be found across the Coastal Plain of Georgia in 2016, though often at levels likely not to cause significant yield loss. However, in fields most severely affected by bacterial blight, yield losses certainly occurred. There are three key tactics to manage bacterial blight. The first is to plant resistant varieties. The second is to manage the crop residue which allows the bacterial pathogen to survive in the field. The third is to rotate affected field away from cotton for at least one season. More details of management of bacterial blight are discussed later in this chapter.

Target spot: Target spot was not as severe in 2015 0r 2016 as it had been in reccnt years, largely because the hot and dry conditions common during much of the season were not conducive for development of the disease. Still, target spot was commonly observed in fields with vigorous growth and irrigation. Target spot was also problematic in some well-managed fields fields with high yield potential. Additionally, new symptoms of target spot, small spots on leaves, bracts and bolls in the upper canopy, were identified in 2016. We continue to asses the importance of these symptoms.

SECTION 2. SEEDLING DISEASES OF 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**. Seed companies continue to incorporate more effective chemistries in their fungicide seed treatment package. Growers can reduce 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:

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!

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.

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. ***CONT.***

CONT.

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).

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.

Avoid chemical injury through the use of excessive amounts or improper application of insecticides, fungicides, or pre-plant herbicides.

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, UGA 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.

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.

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.

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*. The tables below includes detailed information on chemical treatments for seedling diseases.

SECTION 3. FOLIAR DISEASES OF COTTON

Target Spot: Target spot is caused by the fungal pathogen ***Corynespora cassiicola*** and is most severe during periods of extended leaf wetness. Target spot is easily identified by the presence of marble-size spots on a leaf that frequently demonstrate a pattern of concentric rings. Infection and premature defoliation typically begin in the lower leaves of the plant and progress up the plant. Significant defoliation can occur very quickly after initial detection of the disease. Defoliated leaves often retain

their green or green-yellow color. Lesions are also found on the boll bracts and possibly on the bolls themselves. Fungicides have been shown to aide in the management of this disease.

Stemphylium Leaf Spot: Stemphylium leaf spot is caused by the fungal pathogen *Stemphylium solani*; however the underlying cause of this disease is actually the result of a deficiency in potassium in the plant. This disease is analogous to Alternaria leaf spot (*Alternaria macrospora*) in Texas. Symptoms of this disease include a sudden reddening of the foliage of the cotton plant and the raqpid appearance of numerous spots with ashy-gray centers and a dark purple margin. The centers of the spots frequently detach from the leaf giving the leaf a shot-hole appearance. The use of fungicides to manage Stemphylium and Alternaria leaf spot diseases has been largely unsuccessful.

Cercospora Leaf Spot: Like Stemphylium leaf spot and Alternaria leaf spot, Cercospora leaf spot (*Cercospora gossypina*) is often linked to a nutrient deficiency in the cotton crop and may form a disease complex with Alternaria mascrospora and Stemphylium solani. Spots begin as small, reddish lesions that larger circular lesions with light brown centers; zonation similar to that of target spot may be observed. As this disease is associated with nutrient deficiencies, fungicides are not considered to be an effective control measure.

Areolate Mildew: Areaolate mildew, cause by the fungal pathogen *Ramularia areola*, is of limited importance in Georgia and is generally confined to the southeastern region of the state, especially during periods of abundant rainfall. The disease is easily identified by the presence of abundant white-to-gray sporulation on the underside of the affected leaves. The affected leaves often drop prematurely resulting in significant defoliation. This disease can be effectively managed with the use of fungicides, especially strobilurin fungicides; however it is not clear at this time how much yield loss is associated with the disease.

Ascochyta (wet weather) blight: Ascochyta blight, caused by *Ascochyta gossypii*, is a disease of sporadic importance in Georgia, especially during periods of cool weather with abundant rainfall early in the season. Hence, young plants are most often affected. The spots in the field can be tentatively diagnosed by the presence of tan lesions bordered by a dark ring; embedded in the lesion are dark fungal structures that appear like pepper grains. Though use of fungicides for effective management has been reported, such is generally considered unnecessary in Georgia. This disease tends to become of little significance as conditions become drier.

Angular (Bacterial) Leaf Spot: Angular leaf spot is caused by the bacterial pathogen *Xanthomonas citri* pv. *malvacearum* and is of increasing importance to cotton producers in Georgia. The disease is most common in periods of extend rainfall. Lesions/spots on the leaves are quite distinctive as they are defined by the veins on the leaf, thus creating the "angular" appearance. This pathogen can also cause water-soaked lesions on the bolls themselves leading to rot. As this is a bacterial pathogen, use of fungicides is not an effective management tool. This pathogen can be seed transmitted and also readily survives in infested crop debris.

Special Notes for 2017- Managing Bacterial Blight and Target Spot

Take-home points for bacterial blight/angular leaf spot

Bacterial blight is caused by the pathogen now known as *Xanthomonas citri* pv. *malvacearum*.
Symptoms of bacterial blight start as tiny water-soaked spots and progress into characteristically angular shapes due to leaf veins limiting bacterial movement. Lesions appear on the upper side of the leaf (though the angular nature of the spots and "water-soaked" appearance is often more visible from the underside of the leaf), turn black as they expand and defoliation may occur. Systemic infections follow the main veins as black streaks; symptoms on the bolls ae characteristically sunken

water-soaked lesions. The lesions can be found at the base of the boll, shielded by the leafy calyx. The bacterial blight lesions are often further infected by opportunistic fungal pathogens which lead to further boll rot. The bacterial pathogen infects the plant tissues through natural openings and through wounds, such as those caused when plants are damaged by blowing sands in windstorm.
The pathogen (and subsequent disease) can occur in a field through planting of infested seed, surivial from a previous cotton crop in crop residue, introduction through infested equipment and, perhaps, wind and blowing rain during storms. Though it is possible, spread of bacterial blight by insects, such as stinkbugs, is unlikely in Georgia.

Losses to bacterial blight are often small in a field; however lossed can be 20% or more when a susceptible variety is planted.

From a study in conducted in 1964, cotton debris on the soil surface still contained the bacterial pathogen for 217 days (Perkins OK). However, cotton debris lost infectivity in 40 to 107 days in moist soil. The pathogen was not present after tissue decomposed. No disease developed if infested residue was buried.

The most economical management of bacterial blight occurs when more-resistant varieties are planted. Incorporation of infected residue into the soil will help with decomposition of of infected debris and reduce inoculum surviving between seasons.

Variety Selection for Management of Bacterial Blight:

Note: unless otherwise noted, ratings for bacterial blight have beem provided by the seed companies. In 2017, UGA Extension cotton variety trials will be more thoroughly rated for bacterial blight to corroborate industry ratings. See UGA Cotton Webpage for more information.

Varieties from Phytogen Cottonseed:

PHY 312 WRF:	**rated "partially resistant"**	PHY 333 WRF:	considered suscpetible
PHY 339 WRF:	**rated "resistant"**		
PHY 444 WRF:	**rated "partially resistant"**		

PHY 487 WRF: considered susceptible; however in UGA field observations, this variety appeared to be at less susceptible to bacterial blight than was DP 1558NR B2RF.

PHY 490 W3FE:	**rated as "resistant"**		
PHY 495 W3RF:	considered susceptible	PHY 496 W3RF:	considered susceptible
PHY 499 WRF:	considered susceptible	**PHY 575 WRF:**	**rated as "resistant"**

Varieties from Delta and Pineland/Monsanto

DP 1646 B2XF:	**rated as "moderately resistant"**		
DP 1639 B2XF:	**rated as "partially resistant"**		
DP 1614 B2XF:	rated as "susceptible"		
DP 1612 B2XF:	rated as "moderately susceptible"		
DP 1558NR B2RF:	rated as "susceptible"	DP 1555 B2RF:	rated as "susceptible"
DP 1553 B2XF:	rated as "susceptible"	DP 1538 B2XF:	rated as "susceptible"
DP 1522 B2XF:	rated as "susceptible"	**DP 1518 B2XF:**	**rated as "resistant"**

NOTE: For Monsanto varieties, a "moderately resistant" variety will express fewer symptoms than varieties designated as "susceptible". A "partially resistant" variety is heterogenous for resistance to bacterial blight; a portion of the plants are resistant and the remaining plants are susceptible. "Moderately susceptible" varieties will experess more symptoms than those that are "moderately resistant" and fewer than those that are "susceptible".

Varieties from Stoneville/Bayer CropScience
Stoneville 5115 GLT: rated as "resistant"

Varieties from Americot/NexGen
NG 5007 B2XF: rated "moderately resistant" (6/10 where 1 is poor and 6 is excellent)

Take-home points for target spot: The most obvious symptoms associated with foliar diseases of cotton are spots and defoliation. The spots on the leaves likely decrease the ability of the leaf to produce the sugars that feed the growing plant and the developing bolls. Premature defoliation (loss of leaves) of the cotton plant may result in one of several scenarios.

First, if only older leaves lower in the canopy are lost, then the defoliation is unlikely to have a negative impact on yield. Older leaves generally are not productive and loss of a limited number of leaves may actually increase airflow and decrease humidity in the canopy.

Second, if premature defoliation extends upward in the canopy and results in loss of active, productive leaves, then yield may be affected. The subtending leaf associated with a boll is important for development of that boll. If such leaves are lost, then young bolls may be aborted or development negatively affected.

Third, if premature defoliation extends to the top of the plant, then the youngest bolls are unlikely to fully develop and open. For these and other reasons, it is important to promote healty leaves and a healthy canopy of foliage.

IF YOU REMEMBER NOTHING ELSE ABOUT TARGET SPOT:

Target spot causes significant premature defoliation of the cotton crop.

Target spot is common in cotton in the southeastern United States.

Target spot will be most severe in fields with rank growth. The risk to target spot can be reduced by careful management of the growth of the crop.

Fungicides (Headline, Priaxor, Quadris, Elatus and Twinline) can reduce premature defoliation resulting from target spot, but typically not Stemphylium leaf spot.

Based upon trial results, timings of applications that most consistently reduce premature defoliation are those that are made during the first and third weeks of bloom; the third week of bloom seems especially critical. (NOTE: growers can verity the best timing for application of fungicides by scouting fields before disease occurs.) Use of Priaxor at first bloom followed by Headline (or Quadris) at second application is an effective way to improve disease control and to minimize the risk of fungicide resistantce. Priaxor is a pre-mix of Headline and Xemium.

No fungicide program yet assessed in Georgia has effectively eliminated premature defoliation when disease is severe.

In our studies, there has been tremendous variability in yield associated with use of fungicides to protect against target spot. It is not uncommon to find little or no yield increase associated with the use of fungicides; however in other cases (typically the most severe) numeric increases of as much as 200 lb/A lint are observed.

Fungicides are an important and valuable tool in the management of target spot; however they are not needed in every field where target spot is observed. Presented at the conclusion of this section is a draft of Risk Index for Target Spot to aide growers in determining where best to use a fungicide.

Where abundant rainfall (or irrigation) and warm temperatures occur during a season, a significant portion of the cotton crop across the Coastal Plain may be affected by target spot. In mild cases the diseased spots are a curiosity; in severe cases up to 80% defoliation may occur across large areas of a field. Target spot may affect all varieties of cotton grown in Georgia, though some may be affected more than others. Excessive cotton growth where periods of leaf wetness are extended is most often associated with outbreaks of target spot.

Rainfall and irrigation help to spread target spot in at least two ways.
First, rain-splash helps to move spores of the target spot pathogen from debris on the soil to lower leaves of the cotton plant, where infection occurs leading to production of leaf spots.
Second, rainfall and irrigation provide the moisture needed for spore germination and infection to occur. Moisture is also important for the production of spores on the spots and for their dispersal and infection of new tissue.

Rainfall and irrigation are critical for the production of cotton in Georgia; however anything that increases periods of leaf wetness, to include dew, will facilitate the development of target spot. Although management of leaf spot diseases will be discussed elsewhere, below are factors that UGA Cooperative Extension believes increases the risk of a cotton crop to target spot. As risk to target spot increases, the potential benefits to use of a fungicide to protect yield also increase.

Factors that are to likely increase risk to target spot of cotton. (See also draft "Risk Index for Target Spot" at conclusion of the Cotton Disease and Nematode Management section):

Cotton planted in short rotation, especially in fields where target spot has been a problem in the past. Rank growth in the field, either because of management of other factor, e.g., variety.
Field receives overhead irrigation.
Abundant rainfall in a growing season coupled with warm temperatures.

Other factors that may contribute to increased risk to target spot include variety selection (research is being conducted now to assess such) and reduced tillage systems (that may allow spores of the fungal pathogen to survive in the crop debris).

Factors to consider for use of fungicides for the management of target spot:

The "final" fungicide program has not been established for the management of target spot; however an effective program will include 1-2 applications of Priaxor, Elatus, Headline, Quadris or Twinline. Priaxor, a premix of Xemium and Headline, is best used on the first application (if needed) and then followed by Headline or Quadris.
Timing of the first spray will vary based upon weather conditions during a season; however considerations for timing will include points below:

Increased risk to the disease (as assessed above).

Detection of small amounts of disease in the field, before the disease has become established and certainly before significant defoliation has occurred. (Note: Best management for any plant disease is achieved by protecting the crop BEFORE disease is established in the field. Because we still have much to learn about target spot and because there are many fields that may not respond to use of fungicides, growers may choose to wait to see if the disease can be found in their field. Such a "wait-and-see" strategy requires careful scouting to assure success.)

Initiation of the fungicide program before the canopy of cotton foliage closes in order to allow for appropriate coverage of the leaves. Current recommendation for initiating a fungicide application on

cotton for target spot is when the crop is between 1 and 3 weeks after first bloom. Depending on conditions, e.g., wetter or drier, the optimal time for beginning a program could change.

Growers should begin to assess the need for a second application of fungicide no earlier than 3 weeks after the first application.

It is currently unclear if some varieties of cotton are more susceptible to target spot than are other varieties; however work continues to answer this important question. **Regardless of variety, the severity of target spot can be minimized by managing cotton growth with PGRs to eliminate rank growth.**

Below are questions commonly asked about leaf spots on cotton:

Question 1. What is causing the leaf spots in Georgia's cotton fields?

Answer 1. There are three factors associated with outbreaks of leaf spots. First is the potassium nutrition in the cotton plant. Insufficient potassium leads to weakened cell walls in the leaves that are more easily breached by fungal pathogens. Insufficient potassium in the cotton crop may be the result of poor soil fertility, or leaching from the soil during periods of heavy rainfall, or during periods of drought when nutrients are not adequately moved into the plant. The second factor, extended periods of wet weather, created conditions favorable for development and spread of fungal diseases, abundant moisture aids in fungal growth and rain-splash and blowing rain aid in spread of disease. From 2015, a dryer-than-normal season may reduce severity of target spot. The third factor is the presence of inoculum (for example spores). Without sufficient inoculum, disease is much less lukely to develop.

Leaf spots found in Georgia's cotton fields include:

Stemphylium leaf spot (most common by far, is linked to nutrient deficiencies)

Alternaria leaf spot (fairly common, sister disease to Stemphylium leaf spot, is linked to nutrient deficiencies)

Cercospora leaf spot (fairly common, is linked to stress and nutrient deficiencies)

Target spot/Corynespora leaf spot (newly identified in Georgia, aggressive in 2009, 2010, 2012 and 2013, less important in 2011, 2014 and 2015 because of drought) is unrelated to nutrient deficiencies.

Ascochyta wet weather blight (not commonly observed but widespread early in 2013 because of abundant rainfall).

Angular leaf spot (bacterial blight), caused by a bacterial pathogen, was observed in some fields in 2011in 2012 but was not of significant importance. **(Angular leaf spot was diagnosed only once in Georgia in 2014 but was more widespread in 2015 and again in 2016.)**

Question 2. Will disease (especially *Corynespora cassicola* (target spot) and *Stemphylium* sp.) that develops in one season predispose the same field to problems next season?

Answer 2. Although the spores of these fungal pathogens 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 from year to year. The deciding factor for this disease will be the weather that occurs in 2017. The drought during the 2014 season and the dry weather and high temperatures of 2015 decreased the risk to target spot but may have increased the risk to Stepmphylium leaf spot. 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. This is likely due to the

relationship between potassium levels in the plant, soil type and weather patterns

The spores of *Corynespora cssiicola* (target spot) that survive between seasons 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 include frequent rain events.

Bottom line: If our fields experience frequent rains and rank growth (target spot) or if potassium levels are low in the cotton plants (Stemphylium leaf spot), we will likely see another severe outbreak of one or both of these diseases.

Question 3. What is the impact of the spots that affect the leaves to the bracts and the bolls?

Answer 3. Three of the pathogens linked to leaf spots (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 cassiicola*, has been linked to boll rots elsewhere in the world**. The fifth, the bacterial pathogen *Xanthomonas citrii* pv *malvacearum*, was found to cause boll rots in Turner and Ben Hill Counties in 2010 and in multiple counties in 2015 in 2016**.

Question 4. How can Headline, Priaxor, Twinline, Elatus or Quadris best be used to control foliar diseases we have now find in cotton fields? Is tebuconazole effective for management of target spot?

Answer 4. Fungicides like Headline, Quadris, Priaxor (a pre-mix of Headline and Xemium), Elatus (a pre-mix of azoxystrobin and solatenol) and Twinline (a pre-mix of pyraclostrobin and metconazole) are fungicides that can be used to manage **target spot**. Appropriate use of these fungicides can reduce the severity of leaf spots, reduce severity of premature defoliation, and protect yields. We continue to assess the use of each of these fungicides. Topguard (flutriafol) is labeled and we continue to assess its efficacy. Although tebuconazole can be legally applied to cotton, tebuconazole does not seem to be as effective against target spot as compared to the other labeled fungicides.

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.

<u>Therefore, growers should consider the following:</u>

If disease that is linked to a nutritional problem, such as Stemphylium leaf spot, or bactrail blight occurs in a field, a fungicide is unlikely to provide effective control.

In the case of target spot/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 target spot/Corynespora leaf spot is severe. Corynespora leaf spot is likely to be most severe during periods of extended wet weather.

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.

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.

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.

SECTION 4. PLANT-PARASITIC NEMATODES AFFECTING COTTON

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.

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, AgLogic 15G 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 Nematicides

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.

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.

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) had 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 loss of Temik and the ease with which seed-treatment nematicides are used in the field, fewer growers no longer ask, "Is AVICTA Complete Cotton (or AERIS Seed-Applied System) AS GOOD as Temik 15G (5 lb/A)?" and should now as "Is AVICTA Complete Cotton or AERIS or Accelron N GOOD ENOUGH for my field and, if not, what other options do I have?".

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 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, it is has been difficult to show consistent yield increases when assessing Vydate C-LV in our trials; **however use of Vydate is certainly an option for growers who seed additional protection from nematodes after cotton seedlings emerge.**

Velum Total Technical Notes

Active Ingredients: Fluopyram + Imidacloprid
Chemical class: Pyramide + Neonicotinoid
Formulation: Soluble Concentrate - Contains 1.50 lbs. FLUOPYRAM and 2.17 lbs. IMIDACLOPRID per gallon
Rate: 14-18 fl oz/A
Mode of action: Nematodes & Diseases : Fluopyram [SDH-Succinate De-hydrogenase (SDHI) inhibitor (FRAC Group 7)] Nematode Spectrum: Nematodes - Root knot, Reniform, Lance
Insects: Imidacloprid [Nicotinic acetylcholine receptor (nAChR) agonist (IRAC Group 4A)
Xylem systemic

AgLogic 15G Q&A from

Q. What is AgLogic Chemical, LLC?
AgLogic Chemical, LLC is an affiliate of MEY Corporation and holds the U.S. Environmental Protection Agency (EPA) registration for AgLogic™ 15G brand aldicarb pesticide and is currently in the process of returning it to the market for the 2016 growing season. Bayer CropScience formerly marketed a similar product under the brand of Temik.

Q. What is AgLogic™ 15G aldicarb pesticide?
AgLogic™ 15G is a carbamate pesticide that contains the active ingredient aldicarb that controls nematodes, a wide range of piercing and sucking pests and certain chewing pests through direct contact with treated soil and systemically from residues absorbed and translocated by the developing root system.

Q. What crops are currently labeled for AgLogic™ 15G?
Currently labeled crops include cotton, peanuts, soybeans, sugarbeets, drybeans and sweet potatoes.

Q. What pests are listed for control on the AgLogic™ 15G label?
Pests controlled include nematodes, thrips, aphids, leafhoppers, lygus, whiteflies and mites. Check the product label for the full list of pests controlled.

Q. Is AgLogic™ 15G expected to perform comparably to its predecessor Temik?
Its performance is expected to be comparable to Temik 15G.

Q. Can I use the same application equipment for AgLogic™ 15G that I used for Temik?
Yes. The same type of application equipment can be used for AgLogic™ 15G that was used for Temik 15G. However, all equipment must be checked and recalibrated to ensure proper flow of the product.

Q. How will AgLogic™ 15G be packaged?

The corn cob grit formulation will be packaged in two 30-lb. bags per box. Later, the gypsum formulation will be sold and distributed in 45 lb. boxes.

Q. Are there special requirements a grower has to meet to be able to buy AgLogic™ 15G?
Yes. Growers must have a current Georgia restricted use pesticide license and pass an on-line certification course in order to purchase AgLogic™ 15G.

Q. Why is a certification course required to buy and use AgLogic™ 15G?
AgLogic Chemical, LLC is firmly committed to the conscientious labeled use and diligent stewardship of AgLogic™ 15G brand aldicarb pesticide in order to ensure the continued long term availability of this valuable pest management product. The dealer and grower certification courses are the first steps in implementing the precautions and measures deemed important to ensure proper distribution, application, use, storage and if necessary disposal of the product.

Telone II and 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 nematicide seed treatments.

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

Southern root-knot nematodes are the key plant parasitic nematode affecting cotton in much of Georgia.

Southern root-knot nematodes are often unevenly distributed in a field; largely as a factor of soil type.

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.

Southern root-knot nematodes tend to prefer the intersticial spaces of sands (spaces between sand particles) for ease of movement in the soil.

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.

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.

Maps can then be drawn to split the field into zones with higher EC values and lower EC values.

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.

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.)

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.

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.

Notes for 2017- Nematode management:

Management of nematodes affecting the cotton crop remains critically important. The availability of Phytogen 487,DP 1558 B2RF and ST 4946, site-specific application of Telone II and availability of Velum Total and AgLogic 15G are three of the most recent innovations in nematode management available to growers in Georgia.

Question 1. If I have a nematode problem in my field, should I plant one of the nematode-resistant varieties?

Answer 1. As a grower you MUST consider this option (see further notes below). Before you make this decision, insure that the nematode problem in the field is caused by southern root-knot nematodes and not others, e.g. reniform, sting or Columbia lance.

Question 2. If I plant one of the root-knot nematode resistant varieties, do I still need to use a nematicide? Am I better off planting a "highest yielding variety" and treating with a nematicide?

Answer 2. The short answer is that these resistant varieties will certainly perform better than susceptible varieties in terms of decreased root-damage and reduced build-up of nematodes in the soil. This does not necessarily translate into increased yield. Recent data demonstrates that even the resistant varieties may benefit from use of a nematicide like Telone II when nematode populations are severe. However, growers who plant root-knot nematode resistant varieites are unlikely to see a benefit to treating the field with an additional nematicide (to include seed-treatment, Velum Total, AgLogic 15G or Telone II.)

Question 3. What is the value in planting a root-knot nematode resistant variety?

Answer 3. As compared to a susceptible variety, root-knot nematode resistant varieties will have less root galling and root damage and much lower populations of nematodes in the field at the end of the season. Planting a root-knot nematode resistant variety is almost like planting a non-host; nematode populations are greatly reduced for the coming season. Resistant varieties with two resistant genes (e.g., DP 1558 B2RF and PHY 487 WRF) have greater resistance to root-knot nematode varieties than do varieties with a single resistance gene (e.g., ST 4946 BRF).

Planting root-knot resistant varieties will a) decrease root damage which leads to better growth of the plants and b) reduced nematode populations which benefits the next time cotton is planted in the field. Root-knot nematode varieties will not always out-yield susceptible varieties; however resistant varieties are less likely to need the protection from nematicides.

Question 4. What is "VELUM TOTAL"?

Answer 4. Velum Total is a new product from Bayer CropScience that has the combined power for management of nematodes and thrips. This product was labeled and available to cotton growers in Georgia for the 2015 planting season. The University of Georgia and Bayer CropScience have cooperated on numerous field trials and results are promising. We continue to assess this product, but for 2016 UGA Extension recommendations will be that Velum Total (14-18 fl oz/A) is an effective nematicide to be used for nematode management in situtations historically appropriate for Temik 15G (5 lb/A).

Further notes on management of nematodes:

Cotton with proven resistance to the southern root-knot nematode: PHY 487 WRF, DP 1558NR B2RF and ST 4946GLB2 are cotton varieties with a measurable level of resistance to **southern root-knot nematodes** (there is no benefit on reniform or Columbia lance nematodes). (Although the seed companies refer to this partial-resistance as "tolerance", it truly is "resistance".) **Note that PHY 487 WRF, DP and DP 1558NR B2RF all have two genes for resistance to the southern root-knot nematode.**

Results from UGA research trials document that benefits to planting the above varieties in a field where southern root-knot nematode is a problem include:

Less damage to the root system than if a susceptible variety was planted.

Signficant reduction in nematode populations in the soil at the end of the season than would be if a susceptible variety was planted.

NOTE: the above benefits contribute too, but do not gurantee, that a more-resistant variety will out-yield a susceptible variety, even where nematodes occur.

Management with AgLogic 15G.

AgLogic 15G will be used in 2017 much as Temik 15G was in the past; 5-7 lb/A for management of nematodes.

Most AgLogic 15G available in 2017 will be in the "gypsum" formulation.

Research continues to compare the efficacy of AgLogic 15G to Velum Total.

SECTION 5. 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 2013, 2014 and 2015, severe outbreaks of Fusarium wilt were observed in Pierce, Tift, Jeff Davis, Evans, Cook, Grady, Thomas and Berrien Counties**. 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 problematic in southeastern Georgia than in other acreas of the state. Fusarium wilt is becoming of increasing concern.

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 root-knot nematode-resistant cotton varieties 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.

SECTION 6. 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.

Assessing Risk to Target Spot in Georgia

A draft of a risk-management tool to be assessed and refined in Georgia/Revised 12 February 2013

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Factor with the **HIGHEST impact** on increased risk to target spot:

Location of the field. The risk to significant outbreaks of target spot seem greatest in SW Georgia, SE Alabama and NW Florida. 25 pts

Location of the field. Field is located in central and SE Georgia. 15 pts

Location of the field. Field is located in eastern Georgia. 5 pts

Factors with **MODERATE impact** on increased risk to target spot:

Field History. Target spot is likely to occur again if fields where it has been severe in the past if environmental conditions are favorable.

Target spot has been severe in the field in the past. 15 pts

Target spot has been observed but has not been severe. 5 pts

Target spot has not been observed. 0 pts

Rank cotton growth. The development and spread of target spot seems closely tied to extended periods of leaf wetness. Foliage within the dense canopy of cotton stays wet longer and is thus more prone to target spot.

Rank cotton with dense canopy. 15 pts

Cotton with complete closure but growth well managed. 5 pts

Cotton with open canopy and good airflow. 0 pts

Irrigation. As above, irrigation can both improve the growth of the cotton plants and extend periods of leaf wetness, thereby increasing the risk to target spot.

Cotton irrigated during day, extending dew period from previous night. 10 pts

Cotton is irrigated at night or early morning to minimize leaf wetness period. 5 pts

Cotton is not irrigated. 0 pts

Extended periods of rainfall and cloudy weather. Such conditions create conditions where disease is favored.

Frequent periods of extended rainfall of cloudy conditions. 10 pts

Rainfall events "normal" for the season. 5 pts

Growing season is extremely dry. 0 pts

Factors with **LOW** impact on increased risk to target spot**:**

Tillage. Spores of the target spot pathogen, *Corynespora cassiicola*, will survive in the crop debris from previous cotton crops. Spore survival is expected to be longer in reduced-tillage conditions and spores may also be splashed to cotton leaves easier from such debris.

Conservation tillage/reduced tillage. 5 pts

Conventional tillage with deep turning. 0 pts

Crop rotation. Although this remains to be proven, it is likely that target spot on cotton will be more severe in fields where cotton is planted behind cotton or in in short rotations. This is because the spores of the pathogen will survive among the debris from recent cotton crops.

Cotton planted behind cotton. 5 points

At least one year of another crop between cotton crops. 0 points

Factor that **MAY have impact** on risk to target spot**. Variety Selection.**
Variety selection. It is likely that some varieties of cotton may be more susceptible to target spot than are others. However it is not clear whether such an increase in susceptibility is because the pathogen can more easily infect the leaves of the cotton plant or because of the growth habit of the variety tends to be more-rank and thus prone to longer periods of leaf wetness. Also, the exact relationship between defoliation and yield loss is not completely understood. For example a variety with more defoliation than another variety may not necessarily yield less.

YOUR RISK
High Risk: Growers with the greatest risk to target spot and most likely to see some benefit to use of a fungicide program are those with a total risk of **40 points or more**.
Moderate Risk: Growers at **moderate risk to target spot** and could benefit from the use of a fungicide are at risk levels from **25 to 35 points**.
Low Risk: Growers with the **least risk to target** spot are those with risk levels below **25 points**.
Timing of fungicide applications: Growers are advised to begin scouting their fields at the approach of first bloom to determine if target spot is present in the crop. From research conducted in Georgia, the optimum timing for an initial fungicide application is sometime between the first and third week of bloom; an additional fungicide application may be needed approximately 3 weeks after the first application.

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 and shorter plants 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 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 problematic and/or irrigated fields that historically result in adversely tall plants. 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. However, the environment (i.e. rainfall or irrigation) dictates the likelihood of excessive growth moreso than most of other factors. Field history often provides insight on the likelihood of excessive growth.

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 responses to other mepiquat-containing PGRs in UGA trials. Several recent 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*.

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 same 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 nearly 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 earlier, 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 require multiple applications and higher rates 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 have received attention for several years. 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 any other advantage, 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 on 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 advantage 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.

Optimal growth control should result in plant height that is harvest efficient while avoiding excessively tall plants that may result in lodging, severe delays in maturity, loss of critical fruit, or obstruction of spray applications. However plants should be sufficiently tall to support adequate fruiting sites for optimal yields while achieving full canopy closure. Any plant growth regulation strategy should attempt to slow terminal growth enough to allow the increasing developing boll load to restrain vigorous growth, with terminal growth ceasing at an optimal plant height. Plant growth regulation strategies that are too weak (late applications, low rates) may result in suboptimally tall plants if growth is vigorous, while aggressive strategies (early/multiple applications, high rates) may result in insufficient plant height if stress is encountered. Therefore, these decisions need to be made on a case-by-case basis.

Visit the UGA Cotton Webpage for information on PGR management of particular cotton varieties.

IRRIGATION

Although cotton is considered to be a relatively drought-tolerant crop, it is an excellent candidate for irrigation, due to its positive response to well timed irrigation. Irrigation is particularly important in areas that frequently have drought in July through August and on sandy soils. Even though it typically appears that ample rainfall is received during the cotton production season this region of the southeast has periods of episodic drought that can cause significant yield reductions. Irrigation may increase yields from a range of none in wet years to more than 800 lb/A, with increases of 200 to 400 lb/A being common. Irrigation should be supplemental to rainfall, as total reliance on irrigation in the absence of periodic rainfall would be difficult for some producers to achieve with system sizing and water supply. The most critical period of water requirement is during the bloom and boll maturation periods. At peak bloom, the plant requires about 0.3 inches of water per day. However, recent UGA research indicated that timely irrigation with moderate rates during squaring (period when potential fruting sites are developing) may also have a strong influence on yields.

Many uncertainties exist as to HOW to irrigate. With the exception of 2009, 2012, especially 2013 and 2015, many years have been characterized by severe, persisting drought, and many irrigated fields have fallen well below expectations in terms of yield and fiber quality. Even in wetter years like 2012 and 2014, short-lived episodic dry spells have been shown to negatively affect yields in several

situations. However, careful consideration is advised during high rainfall or wet years as excessive irrigation can also reduce yield potential. It is advised to implement a sound irrigaton scheduling strategy during any year.

A recent publication developed by Cotton Incorporated, "Cotton Irrigation Management for Humid Regions", is an excellent resource for growers that provides a broad, general overview of cotton irrigation for our region. This publication is available online at:
http://www.cottoninc.com/fiber/AgriculturalDisciplines/Engineering/Irrigation-Management/.
In the past, irrigation of cotton prior to blooming was initiated when plants began to wilt or exhibited stress by mid-day. However, research has indicated that once cotton begins to wilt, it has already been under physiological stress for some time and yield potential has been lost. Prior to bloom cotton will utilize 0.75 to 1 inch of water per week, which is most important during squaring (7-leaf stage to first bloom). Thus, under hot and dry early season conditions to optimize yield potential the crop should be irrigated at 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 in Table 1. Rain gauges should be used to measure the water received from rain and the amount supplied by irrigation. An example of how to use these values is included below.

Table 1. Cotton Irrigation Schedule Suggested for High Yields

Crop Stage	Inches/Week	Inches/Day
Week beginning at 1st bloom	1.0	0.15
2nd week after 1st bloom	1.5	0.22
3rd week after 1st bloom	2.0	0.30
4th week after 1st bloom	2.0	0.30
5th week after 1st bloom	1.5	0.22
6th week after 1st bloom	1.5	0.22
7th week and beyond	1.0	0.15

Examine the crop during the 7th week and 8th week of bloom to determine if irrigation should be terminated. Additional irrigation may be needed on deep sands, during hot and dry weather, and in windy conditions. It is generally recommended that irrigation be terminated when a noticeable number of bolls have opened, especially when the majority of harvestable bolls are located on lower plant nodes. However, if the majority of the targeted harvestable bolls remain relatively immature when only a few lower bolls begin to open, irrigation may still be required for a short time. Irrigation termination can be a difficult decision. A final irrigation event is often applied when the crop begins to open. Commonly, NO additional irrigation is applied once the crop reaches 10% open boll to minimize problems with boll rot, hard lock, light spot, and other fiber quality issues. Common sense factors for irrigation scheduling and reccomended application amounts include prevailing weather patterns and predictions, available soil moisture, and time of year.

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. Additionally, as stated above over-irrigating can cause yield losses and excessive vegetative growth. Growers attempting to achive high yields should consider implementing a very roubust irrigation management plan, which could include the use of advanced irrigation scheduling tools that include but are not limited o consultants, soil moisture sensors, and online or smartphone app schedulers.

Irrigation Example

Step 1. The soil type of the field is a Tifton loamy sand. In Table 2, the average available water holding capacity is 0.9 inches/ft. Assuming a rooting depth of 2 feet, the total available water is 1.8 inches (2 ft x 0.9 inches/ft).

Step 2. If the cotton crop is determined to be during the 3rd week of bloom. From Table 1, the daily water use by the crop is 0.3 inches/day.

Step 3. Determine replacement water amount by setting the lower allowable limit of available water in the profile. For this example, we will use a typical value of 50% allowable depletion (i.e. only 50% of the water in the root zone will be allowed to be depleted). Therefore, 0.9 inches of water will be required to replace the water used (1.8 inches x 0.50).

Step 4. Determine the amount of irrigation to apply by dividing the amount to be replaced by an irrigation efficiency from Table 3. (There are always losses between water pumped and water actually reaching the crop, such as evaporation, drift, etc.). In this example, we will assume a fairly new center pivot with optimal efficiency, at 88%. Thus, amount to apply = 0.9 inches / 0.88 = 1.02 inches.

Step 5. Determine the frequency of irrigation by dividing the amount of water replaced by water use per day. For example, frequency = 0.9 / 0.3 = 3 days.

Step 6. In this example, it would be necessary to apply 1.02 inches every 3 days to maintain 50% available water in the Tifton loamy sand soil profile for cotton in the 3rd week of bloom. Any rainfall received would be subtracted from the amount to apply.

It is important to note that typically an application amount greater than 0.75 inches results in runoff. This means that you will lose any addional water over 0.75 inches, thus it is recommended that you not exceed this amount in any one single application. This is also the case with rainfall. High intensity rainfall events can often become runoff too, and it is recommended that a producer carefully manage for rainfall. It is more beneficial for the crop if the required 1.02 inches were split into two applications of 0.51 inches every 1.5 days. If you have a pivot so large that it cannot make a round through the field in the calculated split time it is recommended that you apply the minimum amount required for the pivot to travel around the field as quickly as possible, and repeat this step as often as needed to reach required irrigation amounts. In most cases more frequent irrigation applications with lower rates are recommended. However, the rates still need to be high enough so that they can infiltrate into the soil.

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.

Table 2. Examples of Available Water Holding Capacities and Infiltration Rates of Soils in the Coastal Plain of Georgia.

Soil Series	Description	Intake (Inches/Hr) for Bare Soil*	Available Water Holding Capacity (inches/Ft)
Faceville	Sandy Loam, 6-12" Moderate intake, but rapid in first zone	1.0	1.3
Greenville			1.4
Marlboro			1.2-1.5
Cahaba	Loamy Sand, 6-12" Loamy subsoil, rapid in first zone, moderate in second	1.2	1.0-1.5
Orangeburg			1.0-1.3
Red Bay			1.2-1.4

Americus	Loamy Sand, 40-60” Rapid permeability	2.0	1.0
Lakeland			0.8
Troup			0.9-1.2
Norfolk	Loamy sand, 12-18” Rapid permeability	1.3	1.0-1.5
Ochlocknee			1.4-1.8
Dothan	Loamy sand and sandy loam, 6-12” Moderate intake	1.0	1.0-1.3
Tifton			0.8-1.0
Fuquay	Loamy sand, 24-26” Rapid permeability in first zone, moderate in second	1.5	0.6-0.8
Lucy			1.0
Stilson			0.9
Wagram			0.6-0.8

* Increase soil infiltration rate in field where conservation tillage methods are used.

Table 3. Examples of Application Efficiency Values for Various Irrigation Systems.

Irrigation System Type	Application Efficiency (%)	
	Attainable	Expected
Center Pivot w/ Impact Sprinklers	85	75-90
Center Pivot w/ Spray-type Sprinklers	95	75-95
Lateral Move w/ Spray-type Sprinklers	95	75-95
Subsurface Drip	95	70-95
Micro-Spray	95	70-95
Trickle	95	75-95
Subsurface Drip	95	70-95
Moving Big Gun	75	60-75

Irrigation Scheduling

The moisture balance or “check-book” method of scheduling described above is a relatively straight-forward means of determining WHEN and an estimated amount of HOW MUCH to irrigate. This method helps a grower keep up with an estimated amount of available water in the field as the crop grows. The objective is to maintain a record of incoming and outgoing water so that an adequate balanced amount is maintained for crop growth. Other methods of irrigation scheduling include more advanced methods or software such as IrrigatorPro (USDA), soil moisture sensors from companies such as Irrometer, Decagon, AquaSpy, AquaCheck, John Deere Water, etc., the Smart Irrigation Cotton App (www.Smartirrigationapps.org) and the UGA EASY Pan (a simplified pan evaporation device). These devices provide near real-time readings of either soil moisture content or soil water tension in the root zone and can identify when water is needed to replenish the root zone. Soil moisture sensors coupled with a sound irrigation strategy will typically provide the highest yield level when compared to other methods because they are providing live readings and current crop water status, while other methods may just be estimates. Research results have shown that the checkbook method, even though most conservative, is not necessarily the most economically feasible method. Especially during years with higher levels of rainfall the checkbook method tends to reduce yields if not properly managed.

As stated earlier, growers with high yield goals should consider implementing a roubust irrigation management plan. However, the grower must evaluate if the implementation of this plan is feasible for their operation. Based on the level of interest the grower should decide if they want to implement a simple plan that they can manage themselves or if they want to go more advanced and either hire a full time employee for irrigation management or hire a consultant to provide recommended irrigation amounts. This decision will be related to farm size, crop produced, and grower investment. Irrigation scheduling does take time, and growers are cautioned against implementing a plan without being properly prepared.

DEFOLIATION, HARVESTING, AND STORAGE

Cotton defoliates much easier when a good boll load has been obtained and available soil nitrogen is nearly depelted 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 the tables below: Cotton Defoliation / Harvest Aid Options (as seen in the 2017 Pest Management Handbook) below for information about rates and combinations of harvest aids. Additionally, the UGA Cotton Defoliant Evaluation Program evaluates several product combinations in both early and later planted cotton, and thus different late-season environmental conditions, since 2010. The results of these product comparisons can be found at www.ugacotton.com.

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 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. The figures on the following page show predicted percent open bolls to NACB (60% = 4.1 NACB).

Relationship between NACB & % Open Bolls
(Bednarz et al. 2002)

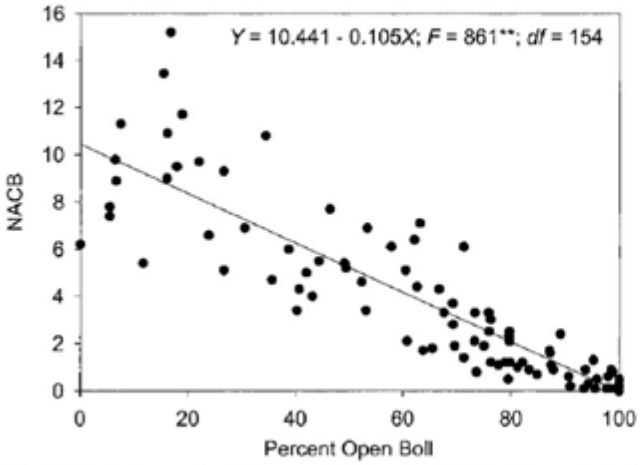


Fig. 1. Nodes from the uppermost first sympodial position cracked boll to the uppermost harvestable boll (NACB) vs. percent open boll in harvest timing studies conducted at the University of Georgia Coastal Plain Experiment Station in 1998, 1999, and 2000. **Denotes significance at the $P = 0.01$ level.

% Open Bolls	NACB
30	7.3
40	6.2
50	5.2
60	4.1
70	3.1
80	2.0
90	1.0
100	0

Harvest Aid Functions

There are four basic functions of harvest aids when applied to cotton. Each process may or may not be required to prepare cotton harvest. An understanding is needed of these processes in order to properly determine products and rates to be chosen.

1. Removal of Mature Foliage
2. Removal of Juvenile Foliage
3. Boll Opening
4. Regrowth Suppression

The first two functions are considered to be involved with defoliation. Defoliation or leaf abscission is a natural plant process. The problem is this natural leaf drop does not occur simultaneously throughout the plant canopy, or in time to effectively facilitate mechanical harvest. Therefore, producers must manipulate the plant to drop its leaves in a relatively short period of time.

While the leaf abscission process is quite complex, it can be simplified as being governed by two major hormones within the plant, auxin and ethylene. Auxin is a growth-promoting hormone that stimulates leaf growth and development. Ethylene can be classified as a senescence or ripening hormone that causes leaf drop. Leaves fall from the plant once ethylene moves from the leaf blade to the base of the petiole and stimulates the formation of an abscission layer. The amount of auxin or ethylene present in the leaves of the cotton plant is related to leaf age. Younger leaves have a more elevated level of auxin, while older leaves have lower levels of auxin and higher levels of ethylene. This is why older leaves are more conditioned for defoliation than younger leaves. Furthermore, because of the hormone balance of younger leaves, low rates of harvest aids often have no effect, and higher rates may actually kill the leaf, leading to desiccation and leaf sticking. Eventually, almost all the leaves on a cotton plant age so they will abscise naturally. However, producers can manipulate

these hormone levels so all the leaves abscise at the same time. When harvest-aids are applied ethylene levels artificially increase so the abscission process begins.

All cotton harvest-aids can be classified into two modes of action, herbicidal and hormonal. Herbicidal harvest-aids injure the leaf, stimulating the production of ethylene (Tribufos [Folex] and PPO Inbitiors (Aim, ET, Blizzard, etc.). Hormonal harvest-aids increase the ethylene concentration in the leaves without causing any injury (Ethephon [various brands] and products containing thidiazuron (Dropp, Freefall, etc). Product selection and application rates should be adjusted to match environmental conditions as they change during the harvest season in order to reduce occurrence of leaf desiccation.

Defoliant Applications

Most harvest aid materials do not translocate or move very far within the plant. Therefore, application coverage is important. To ensure adequate foliar coverage use the proper spray pressure, ground speed and nozzle size in order to apply the desired spray volume in accordance of label instructions.

WATER VOLUME CAN SIGNIFICANTLY IMPACT OVERALL PERFORMANCE, THE MORE WATER THE BETTER (SHOOT FOR 15 GPA)

Be sure to consider harvest when making defoliant applications and treat enough acres to anticipate harvesting the crop 10 to 14 days after application. Leaf drop should start in about four days and be complete in about 10 days. Rainfall occurring after applications can affect defoliant activity. Be sure to consider weather forecasts when making applications and pay attention to rain-free periods of particular products. Thidiazuron is of particular concern, since it requires a 24 hour rain-free period. Information on particular products and rain-free intervals, optimum temperatures for activity, and relative product performance can be found in the 2014 Mid-South Cotton Defoliation Guide (by D. Dodds, D. Reynolds, L. Barber and T. Raper) at http://www.mississippi-crops.com/wp-content/uploads/2014/09/2014-Cotton-Defoliation-Guide_Final.pdf

In 2016, issues regarding adequate defoliation occurred when proper products, rates and applications were implemented. Every situation is different, but many of these cases were related to the dry conditions followed by some rainfall from the tropical systems resulting in a “dryland switch” which prevented defoliant from reaching deep into the canopy. Where excessive regrowoth has already occurred, defoliation can be difficult and may require follow-up applications (or preconditioning). In other cases, the dry conditions affected the effectiveness of defoliants (especially hormonal) as plants were suffering from extreme moisture deficit stress. In either case, normally excellent treatments were less than adequate, and show examples of why time should be spent assessing the condition of the crop and the effectiveness of defoliants each year to ensure desired results.

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

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 as basic recommendations. Always observe label restrictions before using cotton harvest aids.

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)*
EARLY-SEASON (highs 90°F plus, lows 70°F plus)			
Defoliation Only (combinations provide more consistent defoliation than a single product)	*carfentrazone* Aim EC	0.75-1 oz.	Add non-ionic surfactant at 0.25% v/v. The potential for leaf sticking is greater during periods of high temperatures.
	carfentrazone + fluthiacet-methyl Display	up-1 oz.	Limited data, adhere to label restrictions, use precaution.
	flumiclorac Resource	4-6 oz.	Add crop oil at 1 to 2 pt/A. Limited data, use precaution. The potential for leaf sticking is greater during periods of high temperatures.
	fluthiacet-methyl Blizzard	0.5-0.6 oz.	Add crop oil at 1 pt/A. Limited data, use precaution.
	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.
	sodium chlorate	3 lb. ai	Apply to mature foliage only. Do not mix with products containing tribufos or ethephon.
	tribufos Def/Folex	1.5 pt.	Reduce rate to 1.25 pt. if above 94°F.
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	1.6-2.5 oz. + 4-16 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	1.6-2.5 oz. + 0.75 oz	Add 0.25 % v/v non-ionic surfactant.
	carfentrazone + fluthiacet-methyl Display	up-1 oz.	Limited data, adhere to label restrictions, use precaution.
	flumiclorac Resource	4-6 oz.	Add crop oil at 1 pt/A. Limited data, use precaution.
	fluthiacet-methyl Blizzard	0.5-0.6 oz.	Add crop oil at 1 pt/A. Limited data, use precaution. The potential for leaf sticking is greater during periods of high temperatures.
	pyraflufen ethyl ET	1.5 oz.	Add 0.5% v/v crop oil.

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)*
EARLY-SEASON (highs 90°F plus, lows 70°F plus)			
Regrowth Control and Defoliation (continued)	*thidiazuron + diuron* (numerous brands)	6.4-8 oz.	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	1.2-2 pt. + 8-16 oz.	Glyphosate WILL NOT provide regrowth suppression when applied to RF cotton. See specific labels for product rates.
Boll Opening and Defoliation	*ethephon* (numerous brands)	2.0-2.67 pt.	
	ethephon (numerous brands) + **ONE OF THE FOLLOWING:** *carfentrazone* Aim EC	1.33-1.5 pt. + 0.75 oz.	Add 0.25 % v/v non-ionic surfactant.
	carfentrazone + fluthiacet-methyl Display	up-1 oz.	Limited data, adhere to label restrictions, use precaution.
	flumiclorac Resource	4-6 oz.	Add 1 to 2 pt./A crop oil. Limited data, use precaution.
	fluthiacet-methyl Blizzard	0.5-0.6 oz.	Add 1 pt./A crop oil. Limited data, use precaution.
	pyraflufen ethyl ET	1.5 oz.	Add 0.5% v/v crop oil.
	tribufos Def/Folex	1-1.25 pt.	
	thidiazuron (numerous brands)	1.6 oz.	
	thidiazuron + diuron (numerous brands)	4-6 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.
	ethephon + urea sulfate FirstPick + **ONE OF THE FOLLOWING:**	1.75-2 qt. +	Likelihood of leaf sticking is increased during periods of high temperatures.
	carfentrazone Aim EC	0.75 oz.	
	carfentrazone + fluthiacet-methyl Display	up-1 oz.	Limited data, adhere to label restrictions, use precaution.
	flumiclorac Resource	4-6 oz.	Add 1 to 2 pt./A crop oil. Limited data, use precaution.
	fluthiacet-methyl Blizzard	0.5-0.6 oz.	Add 1 pt./A crop oil. Limited data, use precaution.
	pyraflufen ethyl ET	1.5 oz.	
	thidiazuron (numerous brands)	1.6 oz.	
	thidiazuron + diuron (numerous brands)	4-6 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.
	tribufos Def/Folex	4-6 oz.	

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)*
EARLY-SEASON (highs 90°F plus, lows 70°F plus)			
Boll Opening and Defoliation (continued)	*ethephon + cyclanilide* Finish 6 Pro + **ONE OF THE FOLLOWING:**	1.33-1.5 pt. +	
	carfentrazone Aim EC	0.75 oz.	Add 0.25 % v/v non-ionic surfactant.
	carfentrazone + fluthiacet-methyl Display	up-1 oz.	Limited data, adhere to label restrictions, use precaution.
	flumiclorac Resource	4-6 oz.	Add 1 to 2 pt./A crop oil. Limited data, use precaution.
	fluthiacet-methyl Blizzard	0.5-0.6 oz.	Add 1 pt./A crop oil. Limited data, use precaution.
	pyraflufen ethyl ET	1.5 oz.	Add 0.5% v/v crop oil.
	thidiazuron (numerous brands)	1.6 oz.	
	thidiazuron + diuron (numerous brands)	4-6 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.
	tribufos Def/Folex	4-6 oz.	
Boll Opening, Regrowth Control, and Defoliation	*ethephon* (numerous brands) + **ONE OF THE FOLLOWING:**	1.33-1.5 pt. +	Limited data are available for some products. Regrowth control is minimal when these products are applied at rates below 6.4 oz.
	thidiazuron (numerous brands)	2.0-2.5 oz.	
	thidiazuron + diuron (numerous brands)	6.4 oz.	
	ethephon (numerous brands) + *thidiazuron* (numerous brands) + **ONE OF THE FOLLOWING:**	1.33-1.5 pt. + 2.0-2.5 oz. +	
	carfentrazone Aim EC	0.75 oz.	Add 0.25 % v/v non-ionic surfactant.
	carfentrazone + fluthiacet-methyl Display	up-1 oz.	Limited data, adhere to label restrictions, use precaution.
	flumiclorac Resource	4 oz.	Add 1 to 2 pt./A crop oil. Limited data, use precaution.
	fluthiacet-methyl Blizzard	0.5-0.6 oz.	Add 1 pt./A crop oil. Limited data, use precaution.
	pyraflufen ethyl ET	1.5 oz.	Add 0.5% v/v crop oil.
	tribufos Def/Folex	6-12 oz.	

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)*
EARLY-SEASON (highs 90°F plus, lows 70°F plus)			
Boll Opening, Regrowth Control, and Defoliation (continued)	*ethephon + urea sulfate* FirstPick **OR** *ethephon + cyclanilide* Finish 6 Pro + **ONE OF THE FOLLOWING:** *thidiazuron* (numerous brands)	1.75-2 qt. 1 0.33-1.5 pt. + 1.6-2.0 oz.	Likelihood of "leaf sticking" is increased when temperatures exceed 94°F.
MID-SEASON (highs 80 to 89°F plus, lows 60 to 70°F)			
Defoliation Only (combinations provide more consistent defoliation than a single product)	*carfentrazone* Aim EC	0.75-1 oz.	Add 1% v/v crop for 0.75 oz. rate. Add 0.25% non-ionic surfactant for 1.0 oz. rate
	carfentrazone + fluthiacet-methyl Display	up-1 oz.	Limited data, adhere to label restrictions, use precaution.
	flumiclorac Resource	4-6 oz.	Add 1 to 2 pt./A crop oil. Limited data, use precaution.
	fluthiacet-methyl Blizzard	0.5-0.6 oz.	Add 1 pt./A crop oil. Limited data, use precaution.
	pyraflufen ethyl ET	1.5 oz.	Add 1% v/v crop oil.
	sodium chlorate	4 lb. ai	Apply to mature foliage only. Do not mix with products containing tribufos or ethephon.
	tribufos Def/Folex	1-1.5 pt.	
Regrowth Control and Defoliation	*thidiazuron* (numerous brands)	3.2 oz.	
	thidiazuron (numerous brands) **OR** *glyphosate* + **ONE OF THE FOLLOWING:**	2.0-2.5 oz. 1.2-2 pt. +	Glyphosate WILL NOT provide regrowth suppression when applied to RF cotton. See specific labels for product rates.
	carfentrazone Aim EC	0.75-1 oz.	
	carfentrazone + fluthiacet-methyl Display	up-1 oz.	Limited data, adhere to label restrictions, use precaution.
	flumiclorac Resource	4-6 oz.	Add 1 to 2 pt./A crop oil. Limited data, use precaution.
	fluthiacet-methyl Blizzard	0.5-0.6 oz.	Add 1 pt./A crop oil. Limited data, use precaution.
	pyraflufen ethyl ET	1.5 oz.	Add 1% v/v crop oil.
	tribufos Def/Folex	1 pt.	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.
	thidiazuron + diuron (numerous brands)	6.4-8 oz.	Limited data are available with these products. Regrowth control is minimal when these products are applied at rates below 6.4 oz.

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)*
MID-SEASON (highs 80 to 89°F plus, lows 60 to 70°F)			
Boll Opening and Defoliation	*ethephon* (numerous brands)	2-2.67 pt.	
	ethephon (numerous brands) + **ONE OF THE FOLLOWING:**	1.5-2.0 pt. +	
	carfentrazone Aim EC	0.75-1 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.
	carfentrazone + fluthiacet-methyl Display	up-1 oz.	Limited data, adhere to label restrictions, use precaution.
	flumiclorac Resource	4-6 oz.	Add 1 to 2 pt./A crop oil. Limited data, use precaution.
	fluthiacet-methyl Blizzard	0.5-0.6	Add 1 pt./A crop oil. Limited data, use precaution.
	pyraflufen ethyl ET	1.5 oz.	Add 1% v/v crop oil.
	tribufos Def/Folex	1-1.25 pt.	
	thidiazuron (numerous brands)	1.6 oz.	
	thidiazuron + diuron (numerous brands)	6.4 oz.	Limited data are available with some of these products
	ethephon + urea sulfate FirstPick + **ONE OF THE FOLLOWING:**	2.0 qt. +	
	carfentrazone Aim EC	0.75-1.0 oz.	
	carfentrazone + fluthiacet-methyl Display	up-1 oz.	Limited data, adhere to label restrictions, use precaution.
	flumiclorac Resource	4-6 oz.	Add 1 to 2 pt./A crop oil. Limited data, use precaution.
	fluthiacet-methyl Blizzard	0.5-0.6 oz.	Add 1 pt./A crop oil. Limited data, use precaution.
	pyraflufen ethyl ET	1.5 oz.	
	thidiazuron	1.6 oz.	
	thidiazuron + diuron (numerous brands)	5 oz.	Limited data are available with some of these products.
	tribufos Def/Folex	6-8 oz.	

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)*
MID-SEASON (highs 80 to 89°F plus, lows 60 to 70°F)			
Boll Opening and Defoliation (continued)	*ethephon* + *cyclanilide* Finish 6 Pro + **ONE OF THE FOLLOWING:**	1.33-1.5 pt. +	
	carfentrazone Aim EC	0.75-1.0 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.
	carfentrazone + *fluthiacet-methyl* Display	up-1 oz.	Limited data, adhere to label restrictions, use precaution.
	flumiclorac Resource	4-6 oz.	Add 1 to 2 pt./A crop oil. Limited data, use precaution.
	fluthiacet-methyl Blizzard	0.5-0.6 oz.	Add 1 pt./A crop oil. Limited data, use precaution.
	pyraflufen ethyl ET	1.5 oz.	Add 1% v/v crop oil.
	tribufos Def/Folex	6-8 oz.	
	thidiazuron (numerous brands)	1.6 oz.	
	thidiazuron + *diuron* (numerous brands)	5 oz.	Limited data are available with some of these products.
Boll Opening, Regrowth Control, and Defoliation	*ethephon* (numerous brands) + **ONE OF THE FOLLOWING:**	1.5-2 pt. +	
	thidiazuron (numerous brands)	2.0-2.5 oz.	
	thidiazuron + *diuron* (numerous brands)	6.4-8 oz.	Limited data are available with some of these products.
	ethephon (numerous brands) + *thidiazuron* (numerous brands) + **ONE OF THE FOLLOWING:**	1.5-2 pt. + 2.0-2.5 oz. +	
	carfentrazone Aim EC	0.75-1.0 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.
	carfentrazone + *fluthiacet-methyl* Display	up-1 oz.	Limited data, adhere to label restrictions, use precaution.
	flumiclorac Resource	4 oz.	Add 1 to 2 pt./A crop oil. Limited data, use precaution.
	fluthiacet-methyl Blizzard	0.5 oz.	Add 1 pt./A crop oil. Limited data, use precaution.
	pyraflufen ethyl ET	1.5 oz.	Add 1% v/v crop oil.
	tribufos Def/Folex	8-12 oz.	

HARVEST-AID FUNCTION	PRODUCT COMMON NAME	BROADCAST RATE/ACRE	REMARKS AND PRECAUTIONS *(The rates below are given in the broadcast amount per acre unless otherwise noted)*
LATE-SEASON (highs below 80°F, lows below 60°F) **In these conditions, proper defoliation may require a preconditioning treatment (see preconditioning section)**			
Boll Opening, Regrowth Control, and Defoliation (continued)	*ethephon + urea sulfate* FirstPick **OR** *ethephon + cyclanilide* Finish 6 Pro + **ONE OF THE FOLLOWING:**	2 qt. 1.5-2 pt. +	
	thidiazuron (numerous brands)	2.0-2.5 oz.	
	thidiazuron + diuron (numerous brands)	6.4-8 oz.	Limited data are available with some of these products.
Defoliation Only (combinations provide more consistent defoliation than a single product)	*carfentrazone* Aim EC	1 oz.	
	carfentrazone + fluthiacet-methyl Display	up-1 oz.	Limited data, adhere to label restrictions, use precaution.
	flumiclorac Resource	4-6 oz.	Add 1 to 2 pt./A crop oil. Limited data, use precaution.
	fluthiacet-methyl Blizzard	0.5-0.6 oz.	Add 1 pt./A crop oil. Limited data, use precaution.
	pyraflufen ethyl ET	1.5 oz.	
	sodium chlorate	4 lb. ai	
	thidiazuron + diuron (numerous brands)	8-10 oz.	Limited data are available with some of these products.
	tribufos Def/Folex + *paraquat* (numerous brands)	1.5 pt. + 1 to 6 oz.	May cause crop desiccation and damage to unopened bolls.
Boll Opening and Defoliation	*ethephon* (numerous brands)	2-2.67 pt.	
	ethephon (numerous brands) + **ONE OF THE FOLLOWING:**	2-2.67 pt. +	
	tribufos Def/Folex	1-1.25 pt.	
	thidiazuron + diuron (numerous brands)	6 oz.	Limited data are available with some of these products.
	carfentrazone Aim EC	1 oz.	Add 1% v/v crop oil.
	pyraflufen ethyl ET	1.5 oz.	Add 1% v/v crop oil.
	flumiclorac Resource	4-6 oz.	Add 1 to 2 pt./A crop oil. Limited data, use precaution.
	fluthiacet-methyl Blizzard	0.5-0.6	Add 1 pt./A crop oil. Limited data, use precaution.
	carfentrazone + fluthiacet-methyl Display	up-1 oz.	Limited data, adhere to label restrictions, use precaution.

HARVEST-AID FUNCTION	PRODUCT COMMON NAME	BROADCAST RATE/ACRE	REMARKS AND PRECAUTIONS *(The rates below are given in the broadcast amount per acre unless otherwise noted)*
LATE-SEASON (highs below 80°F, lows below 60°F) In these conditions, proper defoliation may require a preconditioning treatment (see preconditioning section)			
Boll Opening and Defoliation (continued)	*ethephon* + *cyclanilide* Finish 6 Pro + **ONE OF THE FOLLOWING:**	1.75-2 pt. +	
	carfentrazone Aim EC	1 oz.	Add 1% v/v crop oil.
	carfentrazone + *fluthiacet-methyl* Display	up-1 oz.	Limited data, adhere to label restrictions, use precaution.
	flumiclorac Resource	4-6 oz.	Add 1 to 2 pt./A crop oil. Limited data, use precaution.
	fluthiacet-methyl Blizzard	0.5-0.6 oz.	Add 1 pt./A crop oil. Limited data, use precaution.
	pyraflufen ethyl ET	1.5 oz.	Add 1% v/v crop oil.
	thidiazuron + *diuron* (numerous brands)	6 oz.	
	tribufos Def/Folex	8-12 oz.	Limited data are available with some of these products.

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**	**BROADCAST RATE/ ACRE**	**REMARKS AND PRECAUTIONS** *(The rates below are given in the broadcast amount per acre unless otherwise noted)*
Initial Preconditioning Treatment	*carfentrazone* Aim EC	1 oz.	Add 1% v/v crop oil.
	carfentrazone + fluthiacet-methyl Display	2up-1 oz.	Limited data, adhere to label restrictions, use precaution.
	ethephon (numerous brands)	0.67-1.33 pt.	
	flumiclorac Resource	4 oz.	Add 1 to 2 pt. crop oil.
	fluthiacet-methyl Blizzard	0.5 oz.	Add 1 pt. crop oil
	glyphosate (numerous brands)	1.2-2 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.
	tribufos Def/Folex	0.5-1.25 pt.	
Follow-up Treatments	**Should include products containing ethephon with harvest aid mixtures listed in the previous table.**		

HARVEST AID WEED MANAGEMENT

PRODUCT COMMON NAME	**BROADCAST RATE/ ACRE**	**REMARKS AND PRECAUTIONS** *The rates below are given in the broadcast amount per acre unless otherwise noted.*
carfentrazone Aim EC	1 oz.	Add 1% v/v crop oil. Effective on morningglory, coffee senna, and tropical spiderwort.
carfentrazone + fluthiacet-methyl Display	up-1 oz.	Limited data, adhere to label restrictions, use precaution.
glyphosate (numerous brands)	1.2-2 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.
paraquat Gramoxone Max, Firestorm, or Parazone	1-4 oz.	Use in combinations with standard defoliation applications. May cause crop desiccation and damage to unopened bolls.
Gramoxone Inteon	3-5 oz.	
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	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.
Firestorm	3.0				
Gramoxone Inteon	2.0	3-5 oz.	10-20	5	
Gramoxone Max	3.0	1-4 oz.	10-20	5	
Parazone	3.0				
paraquat					For desiccation of weeds and cotton regrowth after defoliation. Add surfactant at 1-2 qt 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.-1.5 pt.	10-20	5	
Firestorm	3.0				
Parazone	3.0				
Gramoxone Inteon	2.0	1-2 pt.	10-20	5	
sodium chlorate	4-6	3-6 lb. ai	15-30	5-10	

PERFORMANCE RATING OF HARVEST AIDS BY FUNCTION

COMMON NAME	FUNCTION				
	Removal of Mature Foliage	Removal of Juvenile Foliage	Boll Opening	Regrowth Suppression	Weed Desiccation
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
PPO inhibitors Aim, ET, Resource, Blizzard	G	F	P	P	F
sodium chlorate	F	P	P	P	F-G
thidiazuron (numerous brands)	G-E	G	P	G-E	P
thidiazuron + diuron (numerous brands)	G-E	G	P	G-E	P
tribufos Def/Folex	G-E	P-F	P	P	P

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 and operation speed 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 generally 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 - Place modules where water will drain away from the module. Do not place modules at the bottom of water ways. 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. If possible, place modules in a north/south position so the sun will hit both sides during the day. 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 - Place modules on a firm surface accessible to trucks in wet weather. 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. Leave enough room in front of the module for the module hauler to get straight with the module for loading. 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° F or a temperature of 120° 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 suggest that some types of these pickers may reduce waste, may reduce trash from soil, stubble or grasses, and may preserve some yield and 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.

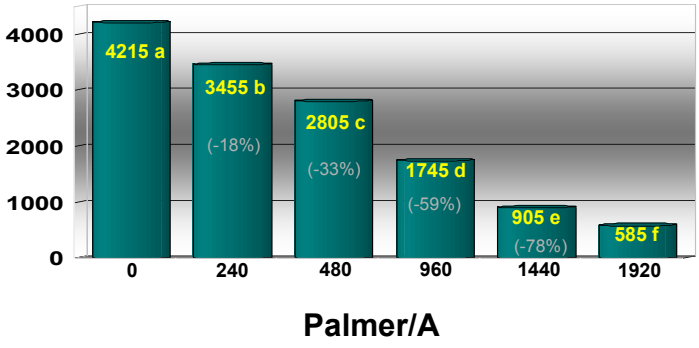
WEED MANAGEMENT IN COTTON

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.

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 the impact of problem weeds. *Crop rotation and properly planned herbicide rotation are also critical components of an herbicide resistance management strategy.*

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



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.

Active ingredient	Some of the products containing the active ingredient
chlorsulfuron	Finesse Cereal and Fallow, Finesse Grass and Broadleaf
diclosulam	Strongarm
imazaquin	Scepter
imazapic	Cadre, Impose, Nufarm Imazapic
imazethapyr	Authority Assist, Extreme, Lightning, Matador, Optill, Praxies, Pursuit, Tackle, Thunder, Thunder Master
sulfentrazone	Authority Assist, Authority First, Authority Maxx, Authority MTZ, Authority XL, Blanket, Broadaxe, Sonic, Spartan, Spartan Charge, Spartan Elite, Sulfentrazone, Zeus

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

CULTIVATION

Although most cultivation disappeared with adoption of Roundup Ready Technology, glyphosate-resistant Palmer amaranth has forced many growers back into cultivating. Cultivation can be used to effectively manage small Palmer amaranth, and other weeds, between cotton rows. If possible, cultivate prior to Palmer amaranth reaching 3 inches and tropical spiderwort reaching 2 inches; also avoid rainfall or irrigation for at least 48 hours after cultivating. *Cultivation can be an effective component of an herbicide resistance management strategy.*

In addition to controlling weeds, cultivation may improve early season cotton growth in tight or crusted soils. On most soils, however, cultivation is usually of no value beyond weed control. For growers who are able to eliminate cultivation, this reduces equipment and labor demands and the subsequent weed flushes, moisture loss, and root damage associated with the practice.

PLANNING A HERBICIDE PROGRAM

Before selecting herbicides, one 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 herbicides with residual activity 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 severe crop injury. Herbicide rates for control of emerged weeds are usually determined by weed size.

Weed Mapping. The first step in a weed management program is to identify the problem which 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. Proper weed identification is critical as different weed species respond differently to various herbicides.

In-Season Monitoring. During the first 6 weeks after planting, check fields every 3- to 5-days to determine the need for postemergence herbicides or cultivation. From the sixth week through canopy closure, check fields weekly to evaluate the success of the weed management program and to determine the need for additional control measures. If weeds are controlled for the first ten weeks, any later emerging weeds will seldom become problems for harvest but could increase the number of seed being added to the seedbank.

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. 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 counties in Georgia. Additionally, common ragweed, goosegrass, horseweed, johnsongrass, and ryegrass resistant to Roundup are scattered across the country. Resistance to PPO herbicides (Valor, Reflex, etc.) is now common across the mid-South, Midwest, and the Carolinas.

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 no longer the case; 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 and technologies.

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. Any production practice, such as reduced tillage, that leads to greater reliance on herbicides will likely increase resistance issues.

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 use of an 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 resistance management strategies.

Nearly all of Georgia's cotton is tolerant to Roundup (glyphosate); corn and soybean acres are similar. In the past, growers relied almost exclusively on Roundup for weed control. Extensive reliance on a single mode of action (the mechanism by which the herbicide kills susceptible plants) over that much acreage puts 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 (fomesafen, many generics) and Valor SX (flumioxazin, many generics) has increased dramatically in cotton and other crops. The use of these herbicides repeatedly will result in selection for PPO-resistant biotypes; as has occurred in the Mid-South, Midwest, and Carolinas. Similarly, over-reliance on Liberty (glufosinate, many generics) for weed control has become more common and this will select for resistance to glufosinate.

It is absolutely essential that herbicide programs 1) are diverse in mode of action, 2) are integrated with other cultural control practices (hand-weeding, tillage, cover crops, crop rotation, other) in order to reduce herbicide selection pressure for resistant weeds, and 3) are implemented in a timely manner. Cotton growers can incorporate diversity in modes of action into a management program by using soil-applied residual herbicides, tank mixing herbicides with Roundup or Liberty postemergence, and using alternatives to Roundup or Liberty at layby; using full rates of these herbicides is also very important even in mixtures.

ON-TARGET PESTICIDE APPLICATIONS ARE CRITICAL TO SUSTAINABILITY

Science is clear that pesticides are currently essential for U.S. farmer's to be able to feed and clothe the world. However, it is critical and will become even more critical that pesticides are used judiciously and carefully to protect the user, the consumer, and the environment. Five of the greatest regulatory challenges facing family farms today include the following: 1) the endangered species act, 2) protecting pollinators, 3) herbicide resistance management plan, 4) the inability to tank mix pesticides during application, and 5) pesticide drift. The most important approach to overcome each

of these challenges is to ensure pesticide applications are made only on-target mitigating any off-target exposure.

A joint effort between The University of Georgia, The Georgia Department of Agriculture, and industry is focusing on helping growers apply pesticides more wisely with in-person meetings across the state. The training focuses on 15 factors that are critical to understand to be successful. This partnership was unique and the first of its kind in an effort to improve the sustainability of agriculture by focusing on precise pesticide applications thereby mitigating off-target issues. In Georgia, 1882 people have been trained by the end of the 2016 season. Contact your local Extension Office for more details.

BURNDOWN IN NO-TILL OR STRIP-TILL COTTON - ALL COTTON CULTIVARS

Cover crops are far superior to winter weeds in reducing weed emergence, reducing impact from Thrips, reducing infestations of radish, primrose, and horseweed, and increasing soil moisture available for the cotton crop in season. Weedy cover crops along with broadleaf cover crops should be killed at least 14 days prior to planting; data thus far notes grass cover crops may be killed closer to planting but soil moisture depletion could be severe. Killing cover crops or weeds prior to planting will avoid soil moisture depletion, allow the soil to warm quicker, reduce cutworm or other insect issues, and allow additional burndown herbicides if needed. Heavy residue from a cover crop will help suppress most weeds (morningglory and nutsedge are exceptions), but growers should consider their equipment capabilities for strip-tilling and planting into residue in deciding when to terminate a cover crop. Burndown herbicides are outlined in Appendix V.

Horseweed has become the most difficult weed to control at burndown because of resistance to Roundup, see the troublesome weed section to obtain specific programs to control this weed.

Cutleaf eveningprimrose and wild radish have traditionally been the most difficult weeds to manage in reduced-till fields. The most effective and economical option for controlling primrose and radish is an application of 2,4-D alone or mixed with any Roundup mixture (such as Roundup + Valor) at least 30 days before planting. For primrose, 2,4-D at 8 to 12 oz/A of a 3.8 lb/gal formulation is sufficient and would reduce the interval between application and planting traditional cotton cultivars; however, rates of 1.0 to 1.5 pt/A are needed for wild radish and 2 pt/A is need for glyphosate-resistant horseweed. Dicamba (Clarity, XtendiMax, Engenia etc.) is the best option for glyphosate-resistant horseweed; it will also control primrose and wild radish although 2,4-D is cheaper and better on both of these weeds.

For growers who do not want to put 2,4-D or dicamba in their sprayers, Liberty or a combination of Roundup plus Valor are options to provide fair (70 to 80%) control of pre-blooming primrose; full blooming primrose or radish will be controlled about 15% better. For wild radish, regardless of growth stage, Roundup mixtures containing Harmony Extra are effective. After radish is in full bloom, Roundup + Valor will provide 75 to 90% control. Additionally, once primrose and radish are in full bloom, good to excellent control should be achieved with Gramoxone plus Direx. Gramoxone + Direx is the single most effective option to control emerged pigweed.

Review labels and the table just below for plant back intervals and other restrictions.

Plant back restrictions and comments for cotton burndown herbicides.

Burndown Selection	Time Interval Before Planting	Special Comments
Roundup or Paraquat	anytime prior to planting	
2,4-D	unknown for many brands; 30 d for Barrage HF and Salvo 5 at proper rates	label suggest cotton can be planted after 2,4-D has dissipated from the soil
Direx	no till: 10 d; strip till after application and before planting: 0 d; *(state label allow these options)*	Do not exceed 1 qt/A, see label for rate on your soil. Suggest avoiding PRE if used preplant within 12 days of planting.
Harmony Extra/Express	at least 14 days	
Valor	strip-till after applying Valor but before planting: ≥10 d; no-till with <30% residue: 28 d and 1" rain; no-till with >30% residue: 21 d and 1" of rain	Do not exceed 2 oz/A if planting within 30 days. **Add 7 days to no-till plant back if using Reflex (generic) PRE.**
Goal	at least 30 d	need 3 rainfalls each at least 0.25 inch
Leadoff	at least 30 d for 1.5 oz/A	one inch rain suggested

PLANTING INTO A SEEDBED FREE OF PALMER – ALL COTTON CULTIVARS

Making certain Palmer amaranth is not emerged at planting remains the first step to success, regardless of cotton technology planted. Herbicides and tillage are both options to prevent Palmer amaranth from being up at planting. For conservation tillage, the use of Valor and/or Direx preplant is critical. Valor is the most effective residual herbicide while Direx plus paraquat (Gramoxone, others) offers the most effective control of emerged plants (Table 1). Follow the appropriate plant back restrictions with these herbicides as noted in Table 2. For conventional tillage production, tillage alone can be effective but the single most effective program would be a split Reflex system where part of the Reflex (plus Treflan or Prowl) is preplant incorporated into moist soil prior to planting (Table 1).

Neither 2,4-D nor dicamba are that effective in controlling Palmer amaranth; especially when compared to Valor (before Palmer emerges) or Gramoxone + Direx once it has emerged.

Table 1. The most effective options to eliminate emerged Palmer amaranth at planting.

Prior to Planting	
CONVENTIONAL TILLAGE	**CONSERVATION TILLAGE**
Option 1 **Reflex 10-12 oz/A + Prowl/Treflan** *apply preplant incorporated 1 to 2 inches deep (preferably within 7 days of planting)*	**Option 1** **Valor with glyphosate or paraquat** *(Palmer < 1" and more than 10 d before planting)*
Option 2 **Keep clean with tillage or herbicides**	**Option 2** **Valor + Direx + paraquat** *(Palmer 1 to 5" and more than 10 d before planting)*
	Option 3 **Direx + paraquat** *(Palmer ≤ 5" and less than 10 d before planting)*

Table 2. Plant back intervals for Valor or Direx applied at burndown.

Herbicide	Time Interval Before Planting	Special Comments
Valor	strip-till after applying Valor but before planting: ≥10 d no-till with <30% ground residue: 28 d and 1" of rain no-till with >30% ground residue: 21 d and 1" of rain	Do not exceed 2 oz/A if planting within 30 days. ***If applying Reflex (or generic PRE), add an additional 7 days to no-till planting intervals.***
Direx	no till: 10 d strip till after application and before planting: 0 d	Do not exceed 1 qt/A, see label for rate on your soil. Suggest avoiding PRE if applied preplant within 12 d of planting.

SELECTING A PREEMERGENCE (PRE) HERBICIDE - ALL COTTON CULTIVARS

For all cotton technologies: Residual at-plant herbicides are required to grow cotton in Georgia. Research consistently shows maximum control is achieved with two effective residual herbicides applied in mixture within 24 hours of planting; include Gramoxone if Palmer is up. Georgia research has shown four consistently effective options including Warrant + Reflex, Direx + Reflex, Warrant + Direx, and Brake F16 (Table 3).

Reflex (fomesafen) is the most effective residual Palmer amaranth herbicide that can be used at planting. It requires very little rainfall/irrigation to activate, often activated with 0.3", and it will lay on the soil for several weeks with minimal degradation. When comparing Warrant vs Direx as a Reflex tank mix partner one should consider 1) Warrant offers more residual Palmer control and will sit on the soil longer waiting on an activating rainfall but 2) Direx offers the greatest ability to control emerged weeds, especially Palmer amaranth. A three-way combination of Reflex plus Warrant plus Direx rarely provides greater residual control when compared to the two-way combinations but may provide more control of emerged plants at planting. Brake F16 is a combination of fomesafen and fluridone providing excellent Palmer control once activated. Additionally for the grower frustrated with Reflex injury, a mixture of Warrant + Direx has proven effective. Always, include Gramoxone + adjuvant with the PRE if any Palmer is emerged.

For auxin technologies: A*t time of publication, neither 2,4-D nor dicamba were registered for use and therefore are not discussed. Contact your local county agent for the latest details.*

Table 3. Most effective herbicide options to apply preemergence (PRE) in cotton.

Preemergence Option	Comments
1. Warrant + Reflex 2. Direx + Reflex 3. Warrant + Direx 4. Brake F16	1. Cotoran can be used to effectively replace Direx in fields with minimal Palmer infestations or for improved control of other broadleaf weeds. 2. Use 10-12 oz/A of Reflex for most soil types except when using the split Reflex program where 8 oz/A PRE following 10-12 oz/A PPI is in order. 3. Warrant rate is typically 48 oz/A for Roundup. If timely with Liberty-based systems, rates of 32-40 oz/A are in order. 4. Direx use rate is typically between 10 and 20 oz/A with lower rates on lighter soils and in conditions where heavy rainfall/irrigation is expected. 5. Brake F16 contains fomesafen and fluridone; 1 pt/A is an effect rate for most soils. Fluridone requires significant rain/irrigation to become active.

Replanting

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. If reworking the seedbed is necessary then the following procedures are suggested:

Strip tillage: Rerun the strip-till rig which should include ripper shanks followed by planting; make certain the operation does not concentrate the previously applied herbicide in the planting zone. After replanting, apply a PRE herbicide mixture that includes both a non-selective herbicide to control emerged weeds/cotton and a residual herbicide. The residual herbicide should be different chemistry than that used with the original planting. It is likely the residual herbicide used with replanting may offer limited residual Palmer control; thus, the first early POST application must be made quickly after replanting (likely 10 d or less).

Conventional Tillage: For those who do not have strip tillage implements, use shallow tillage such as light disking. Do not re-bed without first disking. Re-bedding without disking can lead to severe injury. The amount of time that has passed and the amount of rainfall that has occurred between herbicide applications and replanting will determine the need for additional herbicides. In general, additional herbicides will be needed when replanting but one should switch residual herbicide chemistry from that used during the first planting.

Roundup, Gramoxone, or Liberty must be included to control emerged weeds and cotton when replanting. Gramoxone or Aim will control small emerged cotton. Liberty is also effective controlling cotton as long as it is not a cotton cultivar tolerant to Liberty.

POST APPLICATIONS - ROUNDUP, LIBERTY, OR ROUNDUP + LIBERTY

Specifics for Roundup (glyphosate) System

GlyTol cotton, Roundup Ready Flex cotton, XtendFlex cotton, and Enlist cotton technologies all have excellent tolerance to glyphosate. Brands of glyphosate with 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 1.13 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.

A number of brand names and formulations of Roundup 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 ammonium salt plus potassium salt or

isopropylamine salt plus 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.

Specifics for Liberty (glufosinate) System

Liberty Link cotton, XtendFlex cotton, and Enlist cotton technologies all have tolerance, in varying levels, to glufosinate. In general, tolerance to glufosinate is as follows: Liberty Link > Enlist > XtendFlex although injury differences are greatly influenced by environment. Cotton if injured, regardless of cultivar, recovers rapidly from injury when treated with just glufosinate.

The Liberty label currently allows three applications of 29 oz/A, for a season total of 87 oz/A. Alternatively, one can apply 30 to 43 oz/A once followed by an application of 29 oz/A, for a season total of a maximum of 72 fluid ounces. Labels allow glufosinate application from cotton emergence until the early bloom stage.

Specifics for Liberty (glufosinate) and Roundup (glyphosate) System

Glytol Liberty Link cotton, XtendFlex cotton, and Enlist cotton technologies all have excellent tolerance to Roundup and varying levels of tolerance to Liberty as noted just above. Tank mixtures of Liberty and Roundup will cause more injury on all cultivars when compared to each herbicide applied alone; these mixtures usually cause 10-20% visual damage. In general, cultivar tolerance to this mixture is as follows: GlyTol Liberty Link $\geq$ Enlist > XtendFlex. The addition of a residual herbicide with this mixture will often increase injury 5 to 15%.

Roundup + Liberty tank mixes have occasionally been antagonistic (reduced weed control), especially when the rate of one or both of the herbicides is reduced. Generally, Roundup does not impact the activity of Liberty, but Liberty can antagonize Roundup especially for grasses.

Any brand of glyphosate or glufosinate herbicide registered for use overtop of cotton may be used in these technologies, unless expressly prohibited by the herbicide label. Application rates, timing of application and maximum use rates per season are the same as noted above in the specifics for Roundup system and specifics for Liberty system.

Protecting Liberty

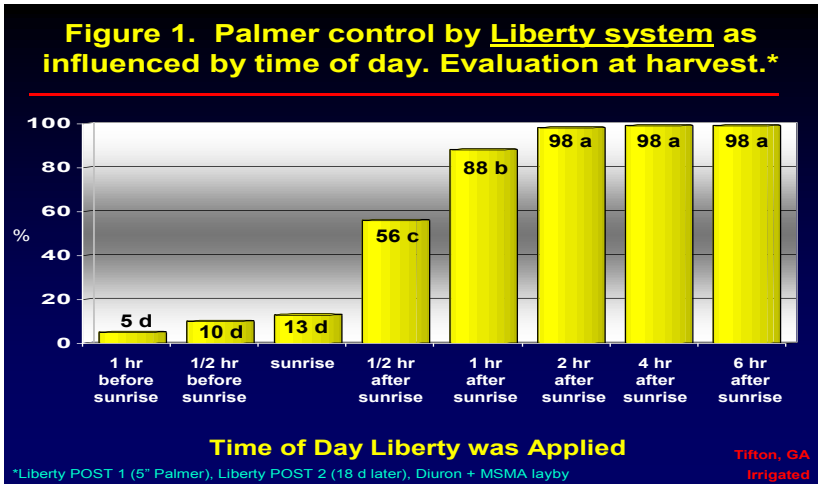
Because of weed resistance to glyphosate and because herbicides with new modes are action are not being developed, Liberty (generics) will continue to play a significant role in cotton weed management for the foreseeable future. It is imperative that growers follow sound resistant management strategies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

PROTECTING LIBERTY FOR FUTURE SUSTAINABILITY: THE DECISION IS YOURS!
1. Do not make more than 2 applications of Liberty per year.
2. Spray Liberty when the biggest pigweed in the field is 3 inches or smaller.
3. Never ever use a reduced rate!
4. Avoid applications within 1.5 hr of sunrise and 1 hr of sunset.
5. Apply at 15 GPA using a speed, spray tip, and pressure that delivers a medium spray droplet.
6. Integrate herbicide programs with 1) hand weeding, 2) tillage, and/or 3) heavy rye cover crop residue.

Application Time of Day for Herbicides Impacts Weed Control

Efforts have been aggressive since 2011 to better understand how time of day impacts the activity of postemergence cotton herbicides. To date, nearly all herbicides studied except Gramoxone are impacted by the time in which they are applied. Liberty is the most vulnerable (Figure 1, top of next page) and *Liberty should not be applied within 1.5 hours of sunrise and 1 hour of sunset.*

Application time of day research has noted differences in activity of Roundup, dicamba, 2,4-D, Reflex, and Diuron. For Roundup, dicamba, and 2,4-D, applications near sunrise or sunset cause below average performance on Palmer amaranth.



Liberty Needs Especially Timely Applications

The optimum weed size for treatment with Liberty 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 and control is still often not adequate. Under stressful conditions, Palmer amaranth and all annual grasses should be 2 inches or smaller when treated. Under dry conditions, applications should be made prior to plant stress causing leaf or stem rolling.

Application Equipment Generating the Ideal Droplet Size for Liberty Alone or With Roundup

Liberty behaves much like a contact herbicide, so good spray coverage is necessary. The label recommends flat-fan nozzles, at least 40 pounds pressure per square inch (psi) and a minimum of 10 gallons per acre spray volume. Ideally, the spray volume is at least 15 gallons per acre. Ultimately the goal with Liberty is to achieve a medium spray droplet; thus, growers must understand the relationship of speed, pressure, and nozzle type to achieve this goal.

POST APPLICATIONS - ROUNDUP, LIBERTY, ROUNDUP + LIBERTY TANKMIXES

In general, growers should focus on mixing Staple, Dual Magnum, or Warrant with Roundup, Liberty, or Roundup + Liberty if they can tolerate the level of injury noted. In general, the more herbicides in the mixture the greater the level of often observed. Two topical applications are generally needed during the season with the second application applied no later than the 8-leaf cotton stage of growth. These applications should always follow a preemergence herbicide and almost always be followed by a layby directed/hooded application.

Assure II, Fusilade DX, Poast, Poast Plus, or Select Max can be mixed with Roundup to control volunteer Roundup Ready corn. Do not mix with Liberty or Liberty + Roundup.

Dual Magnum (*S*-metolachlor) can be applied overtop from emergence until 100 days prior to harvest. Crop injury with Dual Magnum in mixture with Roundup or Liberty is typically minor, with necrotic speckling noted on leaves contacted. This injury is usually 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 1) additional adjuvants or some insecticides are included in mixtures 2) when applications are made when heavy dew is on the cotton 3) when the weather is extremely hot and humid and/or 4) when soils are saturated at time of treatment. Three way-mixtures (Roundup + Liberty + Dual Mag.) at times can cause significant injury with occasional leaf drop; no negative impact on yield has been noted with research thus far as long as the cotton is treated prior to the 8-leaf stage.

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 a.e. of glyphosate plus 1 pint of Dual Magnum.

The addition of Dual Magnum in the mixture will have no effect on emerged weeds. 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 18 to 30 days often noted), and suppression of yellow nutsedge and spreading dayflower. Dual Magnum 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 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 with Roundup or Liberty.

Envoke (trifloxysulfuron) mixed with Roundup should only be directed in cotton as injury from topical applications can be significant. Do not mix with Liberty and apply topically. The label will allow Envoke 0.1 oz/A to be mixed with certain brands of Roundup and applied overtop of Roundup Ready Flex cotton from the 5-leaf (prefer 7-leaf) to the 12-leaf stage. Envoke will improve control of nutsedge, hemp sesbania, and larger *Ipomoea* morningglory (not smallflower mg) compared to Roundup alone.

Outlook (dimethenamid) was recently registered for overtop application in a mixture with Roundup. Data has not been generated with Liberty mixtures; thus, avoid those applications at this time. Dimethenamid can be applied overtop from the first true leaf stage until mid-bloom. Make only one application per year. Similar to S-metolachlor and acetochlor, dimethenamid has no activity on emerged weeds but it will provide residual control of pigweed species, including Palmer amaranth, and annual grasses. Research to date has shown that crop tolerance is similar to that with S-metolachlor or acetochlor.

Staple LX or Pyrimax (pyrithiobac) can be mixed with Roundup or Liberty and applied overtop of cotton from the cotyledonary stage until 60 days prior to harvest. At this time, suggest avoid mixing Staple with Roundup + Liberty as more injury data is needed. Rates are typically between 1.5 to 2.0 fl oz/A when mixed with Roundup or Liberty except when attempting to control non ALS-resistant Palmer amaranth with a Roundup + Staple mixture. Staple should be applied at a rate of at least 2.6 fluid ounces to control 1" Palmer amaranth. Salvage applications of Staple allow increased rates up

to 3.8 fluid ounces (see labels) which would be needed for larger pigweed; injury is a concern with high rates.

Staple would likely 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). Staple or Pyrimax will give residual control of susceptible weeds such as pigweed species. Palmer amaranth resistant to these products and other ALS inhibitors is present in MANY Georgia fields.

Mixing Staple with Roundup or Liberty will increase injury. Applied overtop, temporary yellowing of the cotton bud is likely. Research has demonstrated that cotton recovers quickly, and there is seldom an adverse effect on yield or maturity. On occasion, however, moderate to severe injury may occur. The potential for significant injury 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 (acetochlor) can be applied topically after cotton is completely emerged but before first bloom. Two applications of Warrant may be made during the season such as one PRE application followed by a POST application or two POST applications. Crop injury with Warrant in mixture with Roundup or Liberty is typically minor, with necrotic speckling noted on leaves contacted. This injury is usually temporary with no adverse effect on yield or maturity as long as the application is made prior to the 8 leaf stage of cotton. Increased injury levels have been observed when 1) additional adjuvants or some insecticides are included in mixtures 2) when applications are made when heavy dew is on the cotton 3) when the weather is extremely hot and humid and/or 4) when applications are made on saturated soils.

Three way-mixtures (Roundup + Liberty + Warrant) at times can cause significant injury with occasional leaf drop; no negative impact on yield has been noted with research thus far as long as the cotton is treated prior to the 8-leaf stage.

Do not tank mix Warrant with Staple or Pyrimax.

Warrant vs Dual Magnum are similar in many ways but there are some distinct differences. Research suggests Dual Magnum is much easier to activate and provides immediate Palmer amaranth control once it is activated while Warrant requires a few days to become active after rainfall/irrigation as the encapsulation is degrading. However, Warrant is far more effective when herbicides lay on the soil 7 to 14 days waiting for rainfall/irrigation. Also, Warrant can be applied preemergence to cotton while Dual Magnum can cause severe cotton injury when applied preemergence to cotton. Neither product should be applied preplant.

POST APPLICATIONS - LIBERTY IN WIDESTRIKE COTTON

LibertyLink cotton was transformed to include the bacterial *bar* gene which codes for an enzyme that effectively deactivates glufosinate (Liberty herbicide). LibertyLink tolerance to Liberty is excellent. In Phytogen's Widestrike cotton, the bacterial *pat* gene was inserted for use as a selectable marker during transformation events for lepidopteran pest resistance. The *pat* gene also codes for the enzyme that deactivates glufosinate. However, tolerance of varieties with the Widestrike trait to Liberty is not complete and some injury is expected with topical Liberty applications. 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, Liberty herbicide can be applied to WideStrike cotton. *However, the grower is liable for any crop injury resulting from the application. Neither Bayer*

CropScience, Dow AgroSciences/PhytoGen nor the University of Georgia recommend or warrant the use of Liberty on WideStrike cotton.

Research throughout the Southeast has not shown significant yield reduction of WideStrike cotton from two Liberty applications at 29 fluid ounces applied to 1- to 2-leaf cotton and again to 5- to 7-leaf cotton. Rates in excess of 29 fluid ounces are discouraged on Widestrike cotton; higher rates cause more burn with possible stunting and leaf drop. The addition of ammonium sulfate and other herbicides is also discouraged. Additionally, application of Liberty 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 yield reduction.

POST APPLICATIONS - ANY CULTIVAR

Envoke (trifloxysulfuron) 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 to avoid injury and 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" 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 these herbicides is common.

Cotton injury is often expressed as yellowing in the growing point and shortened internodes. Some degree of crop response can almost always be expected. In many 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. Growers are encouraged to not apply Envoke 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, Assure II, Fusilade DX, Poast, Poast Plus, Select or Select Max should be avoided. Separate applications of Envoke and these products by at least 3 days if the grass-control herbicide or mepiquat is applied first or 5 days if Envoke is applied first.

Staple LX or Pyrimax *(pyrithiobac)* 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 does not exceed 5.1 fluid oz/A.

If applied in a timely manner, many broadleaf weeds are controlled with notable exceptions including the following: lambsquarters, ragweed, sicklepod, spurge, tall morningglory, or tropic croton. Most susceptible broadleaf weeds should not be taller than 3 inches. Palmer amaranth and Prickly sida must be 1 inch or less for consistent acceptable control. Palmer amaranth resistance to ALS-chemistry is common across GA.

Do not mix with Assure II, Fusilade DX, Poast, Poast Plus, Select or Select Max because antagonism (reduced grass control) is often observed. When making sequential applications with postemergence grass-control herbicide, apply the Staple/Pyrimax 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 without injury concerns. These

products control annual and perennial grasses but are ineffective on nutsedge and broadleaf weeds. Poast, Poast Plus, Select, and Select Max tend to be the more effective options over a range of annual grass species and environmental conditions. Tank-mixing broadleaf herbicides, such as Staple or Envoke, with these postemergence grass-control herbicides is not recommended.

DIRECTED APPLICATIONS - ROUNDUP AND/OR LIBERTY SYSTEMS

Liberty should not be applied as a layby treatment as a means of sound resistant management, regardless of cotton technology. It is critical that it is preserved for topical applications; other options exist and are more effective. Thus, the discussion below will focus on Roundup or MSMA layby applications. If cotton is not tolerant to Roundup, apply only MSMA mixes.

Palmer amaranth is the dominant species present across the state and an application of diuron (Direx, other) + MSMA or Suprend + MSMA is suggested as these are the most effective options; only Gramoxone + diuron (under hoods, no crop contact) is more effective.

Diuron + MSMA has many strengths with only two weed control weaknesses. First, it lacks control of larger (>3") morningglory. When both Palmer amaranth and morningglory need to be controlled then one should include 1) Aim, 2) Envoke, or 3) ET with diuron + MSMA; make certain cotton is large enough for the selected product. Second, Diuron + MSMA lacks grass control. If Palmer amaranth is not problematic but grasses larger than 0.5" are an issue, Roundup mixtures will be more effective.

Potential partners with Roundup to post-direct include Aim, Caparol, diuron, Dual Magnum (generics), Envoke, ET, Fierce, Staple, Pyrimax, Suprend, Valor (generics), Warrant, and Zidua. Each of these mixtures will be discussed below.

Aim and ET mixed with Roundup will improve control of larger morningglory. Additionally, Aim will provide excellent control of emerged tropical spiderwort that is 4" or less. Cotton should be at least 20" 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 Roundup will improve control of morningglory and pigweed. Caparol at 2 pints or diuron (Direx 4 L, other) at 1.5 pints will provide some residual control of small-seeded broadleaf weeds, such as pigweed, if activated. Diuron is usually more effective on Palmer amaranth than Caparol. Cotton should be at least 12" tall before directing Caparol or diuron at these rates. Occasionally, mixing Caparol or diuron will reduce grass control by Roundup. This is most likely to occur under dry growing conditions with large grasses. Do not reduce the Roundup rate when applying these mixtures.

Dual Magnum, Warrant, or Zidua mixed with Roundup will not improve control of emerged weeds but, if activated, will provide residual control of annual grasses, (Texas millet is only suppressed), pigweeds, and some other broadleaf species. Dual Magnum and Warrant will provide doveweed and tropical spiderwort control; data is not available with Zidua. Warrant can be directed anytime up to first bloom; Zidua can be directed from 5-leaf state to first bloom, and Dual Magnum can be directed to cotton from 3" tall until 80 days prior to harvest.

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

Fierce is a mixture of the active ingredients in Valor and Zidua and can be used in the same manner as Valor discussed just below. When mixed with Roundup, it is a very effective herbicide providing control of emerged weeds and residual control once activated. Notable escapes from the residual component of the program include Texas panicum and nutsedge. Compared to Valor, greater grass control and longer residual control can be observed with Fierce.

Staple LX or Pyrimax mixed with Roundup will improve control of hemp sesbania, morningglory (except tall morningglory), spreading dayflower, tropical spiderwort, and glyphosate-resistant Palmer amaranth that is non-ALS resistant. Excellent residual control of susceptible weeds will also be observed once Staple is activated.

Suprend is a mixture of the active ingredients in Caparol and Envoke. Suprend mixed with Roundup will improve control of larger morningglory, nutsedge, and pigweeds. It provides excellent residual control of susceptible weeds. Cotton should be at least 8" tall when directing.

Valor SX mixed with Roundup will improve control of doveweed, larger morningglory, Florida pusley, tropical spiderwort and glyphosate-resistant Palmer amaranth. Outflank, Panther, and Rowell have the same active ingredient as Valor, as well as several other generics. Cotton should be at least 18" tall with a completely "woody" stem 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 Roundup brand requires adjuvant. DO NOT use crop oil concentrate, methylated seed oil, organo-silicone adjuvants, or any adjuvant product containing these. Valor, once activated, will provide excellent residual control of pigweed species including Palmer amaranth, Florida pusley, and many other broadleaf weeds. Valor has a very favorable rotational package, see label.

DIRECTED APPLICATIONS - ANY CULTIVAR

A number of herbicide combinations are available for directed application to any variety of cotton. More common options include Caparol + MSMA, Cobra + MSMA, Cotoran + MSMA, Direx + MSMA, Suprend + MSMA, and Valor SX + MSMA. Dual Magnum, Warrant, Aim, and ET may be added to some of these combinations. Staple or Envoke could be used at layby as well.

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". Except for Aim, ET, MSMA, and Cobra plus MSMA, the options listed above will also provide some residual control of sensitive weeds.

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. 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.

Annual Weeds

Aim or ET are also registered for use as defoliants. Good desiccation of morningglory and cocklebur has 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.

Roundup can be applied to tolerant varieties seven or more days ahead of harvest regardless of percentage of open bolls.

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 16 to 32 oz/A of Gramoxone 2 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; usually one should wait 5 days and then pick as soon as possible. Gramoxone will desiccate most annual weeds with Florida pusley being an exception. Cotton must be harvested in a timely manner bark and cotton plant death can occur rapidly.

Perennial Weeds

Roundup can be applied in the fall to control or suppress perennial weeds for the following year. Ideally, it should be applied after defoliation for improved coverage and this will allow application only for infested areas. Maximum labeled use rates are suggested for nutsedge, trumpetcreeper, common milkweed, bermudagrass, horsenettle and hemp dogbane. *Apply Roundup at least 10 days before the first killing frost.*

MANAGING THE MOST TROUBLESOME WEEDS IN COTTON

Bermudagrass: The most effective method to manage bermudagrass populations are fall applications of Roundup (high rates, sequential applications 10 d apart, at least 10 d before frost) followed by Roundup or postemergent graminicides in the following crop. Postemergence graminicides (Select, Select Max, Fusilade DX, Assure II) are the most effective option when bermudagrass has runners less than 6"; however, a tank mix of Roundup plus graminicide would likely be the most effective option when labeled. Liberty provides little lasting control.

Doveweed: Roundup will only suppress doveweed while Liberty has even less activity. Dual Magnum will control doveweed if activated before germination; preliminary data suggest Warrant is similarly effective. Gramoxone applied with hooded sprayers will control emerged doveweed. And, directed applications of Valor plus MSMA, Valor plus Roundup, and diuron plus Roundup appear to be fairly effective on emerged plants.

Florida pusley: Florida pusley can be controlled by Roundup but ONLY if applied at the full rate when the weed is very small (1" or less) and under ideal conditions; multiple applications are sometimes necessary. Roundup is more effective than Liberty. However, the key to success begins by controlling the weed before emergence with residuals. Treflan, Prowl, Cotoran, diuron, and Warrant control this weed if applied properly and activated. Additionally, one should include residual herbicides in with POST and layby applications to prevent the weed from emerging.

Glyphosate-Resistant Horseweed: Glyphosate-resistant horseweed (also called marestail) has been confirmed in most states surrounding Georgia and is expected to be present in 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. Glyphosate-resistant horseweed can be controlled by tank mixes of Roundup plus 0.95 pound a.e. of 2,4-D (2 pt/A of 3.8 lb a.e./gal formulation) or Roundup plus 0.25 lb active/A of dicamba (0.5 pt/A of Clarity). The tank mix with 2,4-D at this rate should be at least 30 days ahead of planting with at least 1" of rainfall occurring between applications and planting. Cotton planting must be delayed at least 21 d after the accumulation of 1" of rainfall following dicamba application according to current dicamba labels. Neither Engenia nor XtendiMax (new dicamba formulations) are currently registered for use in XtendFlex cotton; however, once registered these products will allow more flexible dicamba rates without plant back intervals in XtendFlex cotton.

Horseweed that germinates in the fall can be controlled by winter burndown programs including 2,4-D or dicamba. However, plants that emerge late in the spring after burndown can become problematic. Valor will not assist in controlling emerged plants but will reduce problems with late-emerging horseweed. Weed scientists in Tennessee have found that residual control from Cotoran applied preemergence is probably the best option to control late-emerging horseweed. Gramoxone should be included with the Cotoran preemergence to kill emerged weeds.

Although somewhat less effective than a tank mix of glyphosate plus 2,4-D or dicamba, a mixture of Gramoxone plus Direx may adequately control horseweed if the mixture is applied when daytime temperatures exceed 75 F. Warm temperatures are critical for success with this treatment.

Liberty (generics) at 36 to 43 oz/A will also control horseweed if applied when daytime temperatures exceed 85 F. Liberty 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. Liberty can be applied any time prior to cotton planting.

Glyphosate-Resistant Common Ragweed: Common ragweed resistant to Roundup has been confirmed in North Carolina. Residual control from Cotoran or Reflex plus diuron applied premergence is effective; Valor applied preplant burndown will also assist in control. Ragweed can be controlled by Liberty POST followed as needed by Envoke.

Glyphosate-Resistant Palmer Amaranth: Palmer amaranth is Georgia's most problematic weed. It is imperative that growers continue to use sound herbicide programs (Tables 4 and 5, below) but also integrate these programs with other control measures, such as hand-weeding, to remove escapes before seed are produced, deep turning to reduce the number of plants emerging (ideally wait 3.5 to 4 years before repeating), and/or using a heavy mulch cover crop to suppress Palmer emergence in conservation tillage. Also, it is imperative that Palmer amaranth is controlled in crops rotated with cotton, and this should be done with minimal reliance on ALS and PPO inhibitors as well as with Liberty products. Because Staple, Reflex, Valor and Liberty are critical in a cotton program to control glyphosate-resistant Palmer amaranth, it is a grower's best interest to prevent or at least slow further selection for resistance to these herbicides.

Table 4.. POST options to control glyphosate-resistant Palmer amaranth with Liberty or Liberty + Roundup Systems[1]
(BE CERTAIN TO INCLUDE PREPLANT, PRE, AND LAYBY TOOLS AS NOTED ABOVE IN TABLE 4)

POST 1 ~17 d after PRE[2]	POST 2 ~ 13-17 d after POST 1[2]	Comments
Biggest pigweed in field 3 inches: **Liberty + Roundup + Dual Mag. or Warrant**[3,4] *or* **Liberty + Dual Mag. or Warrant** --- *No pigweed emerged:* **Roundup + Staple, Dual Mag. or Warrant**	*Biggest pigweed in field 3 inches:* **No 3-way mixture suggested** *or* **Liberty + Dual Mag. or Warrant** --- *No pigweed emerged:* **Roundup + Staple, Dual Mag., or Warrant**	[1]Glytol LibertyLink, XtendFlex, or Enlist Cotton Cultivars Only. UGA data suggests tolerance to Liberty is as follows: Liberty Link > Enlist > XtendFlex>>>Widestrike. [2]Day interval assumes PRE residual herbicides were ideally activated. **[3]Mixtures of Liberty + Roundup + residual will be more injurious than Liberty+ residual or Roundup + residual; experiment on limited acres. Injury of 25% with leaf shed has been observed.** [4]Tank mix can provide less grass control than Roundup alone, especially for goosegrass. Use full rate of Roundup. Base Liberty rate on pigweed size.

Table 5. . Managing glyphosate-resistant Palmer amaranth with a Roundup-based program.[1]

Prior to Planting	Preemergence (PRE)[2]	POST 1 at 13 d after PRE[3]	POST 2 at 14 d after POST 1[3]	Layby at 18 d after POST 2[3]
CONVENTIONAL PROGRAM 1 **Reflex[4] 10-12 oz/A + Prowl/Treflan** *incorporated 1 to 2"deep* *(prefer within 7 d of planting)*	**1. Warrant + Reflex** **2. Direx + Reflex** **3. Direx + Warrant** *Direx 10 to 20 oz/A;* *Reflex 8 to 10 oz/A;* *Warrant 32 oz/A*	**Roundup + Staple or Pyrimax[5]** *unless no Palmer up or ALS-resistant Palmer present; if so then apply:* **Roundup + Warrant or Dual Magnum[6]** *no Palmer up*	**Roundup + Dual Magnum or Warrant[6]** *no Palmer up*	**Direx + MSMA[7]** *Palmer < 5"; add Envoke to improve morningglory control*
CONVENTIONAL PROGRAM 2 **Palmer free at planting with tillage or herbicides**	**1. Warrant + Reflex** **2. Direx + Reflex** **3. Direx + Warrant** **4. Brake F16** *Direx 10 to 20 oz/A;* *Reflex 12 oz/A;* *Warrant 3 pt/A;* *Brake F16 1 pt/A;*			
CONSERVATION TILLAGE **Valor with Roundup or paraquat[2]** *Palmer < 1" & over 10 d before planting*	**1. Warrant + Reflex** **2. Direx + Reflex** **3. Direx + Warrant** **4. Brake F16** *Direx 10 to 20 oz/A;* *Reflex 12 oz/A;* *Warrant 3 pt/A;* *Brake F16 1 pt/A*			
Valor + Direx + paraquat[2] *Palmer 1-5" & over 10 d before planting*				
Direx + paraquat[2] *Palmer ≤ 5" & within 10 d of planting*				

[1]Follow all herbicide label use restrictions and plant back intervals.
[2]Add paraquat plus adjuvant at burndown and PRE if Palmer is emerged. If Direx (diuron) is applied burndown suggest avoiding PRE.
[3]Day interval assumes PRE residual herbicides were activated in timely fashion.
[4]The split Reflex program including preplant incorporated and PRE Reflex applications is the most effective program in cotton.
[5]Replace Staple/Pyrimax with Warrant if carryover or ALS-resistance is an issue.
[6]Suggest not applying Warrant or Dual overtop after 7-lf stage because of injury; if making these late applications anyway suggest Dual.
[7]Add adjuvant. Suprend + MSMA is as effective as Direx + MSMA in controlling Palmer.

Goosegrass: Liberty is marginally effective on goosegrass at best; thus, a program must be developed to prevent an increase in goosegrass populations where Liberty is used heavily. The use of at-plant herbicides, such as Warrant, Prowl or Cotoran, is the first step to success. Roundup is an effective option although the weed must be small and may require repeated applications, the addition of residual herbicides such as Dual Mangum or Warrant should be included with Roundup. Mixing Roundup and Liberty will reduce the activity of Roundup on goosegrass; thus, for goosegrass apply Roundup without Liberty if possible. POST grass herbicides can also be effective but must be applied very timely. Goosegrass resistant to Roundup and POST grass herbicides are present in nearby states.

Hemp Sesbania: Currently no data exists for the weeds response to Liberty. For Roundup, hemp sesbania is very difficult to control after the first true leaf. When it is expected to be a problem, soil-applied herbicides such as Cotoran are in order. Follow with Roundup plus Staple postemergence and a postemergence-directed application of a conventional 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 with the cotton size restriction delaying Envoke application until after 5 leaf, sesbania may be greater than 3" at time of treatment which would likely end up providing poor control.

Morningglory: Liberty provides outstanding control as long as the proper rate, appropriate weed size, and adequate weed coverage are achieved. For Roundup, a single application rarely provides adequate control. It will, however, halt growth of small morningglory so that the weed can be taken out with cultivation or a second application. For morningglory (except the species tall morningglory) 3 inches or larger, the addition of Staple with Roundup is an effective option. Envoke is also a very effective option on *Ipomoea* morningglory but when mixed with Roundup it should be applied as a sloppy directed application. Cotoran applied preemergence is useful.

At time of layby, conventional chemistries such as MSMA plus Caparol, Cobra, diuron, Suprend, or Valor would be more effective than Roundup. Diuron plus MSMA has become a standard layby mixture and even though it is more effective than Roundup, the addition of Aim, Envoke, or ET with diuron plus MSMA is suggested. If one chooses to use Roundup, the addition of Aim, Caparol, diuron, Envoke, ET, Staple, Suprend, or Valor would be beneficial (see labels for application timings and cotton sizes).

Nutsedge: Although Liberty provides a visual perception of control, it really is not an effective option. Two applications of Roundup at the maximum use rate normally controls yellow and purple nutsedge. Good results also have been obtained with the full rate of Roundup 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 Roundup 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.

Perennial broadleaf weeds, such as horsenettle, trumpetcreeper, common milkweed, and hemp dogbane, are primarily a problem in conservation tillage. 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 are usually needed. Harvest-time applications of Roundup are also an option to suppress perennial weeds for the following year (see preharvest section).

Perennial broadleaf weeds can be suppressed or controlled with multiple applications of Roundup applied to tolerant cotton. Later applications are generally more effective on perennials, and two applications are more effective than one. Directed sprays are likely far more effective with applications made during mid- or late-season because of improved coverage.

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. Once dicamba and 2,4-D become registered for use in tolerant cotton cultivar technologies, these produces will prove beneficial in the control of perennial broadleaf weeds.

Roundup Ready corn (volunteer): Assure II, Fusilade DX, Select or Select Max may be applied alone or mixed with Roundup to control Roundup Ready corn in Roundup Ready cotton. See appendix 5 for suggested rates and application timings. Liberty will burn corn back but most will survive; do not mix grass herbicides with Liberty.

Roundup Ready soybean (volunteer): Liberty will be extremely effective in controlling RR soybean. For a Roundup-based program, Cotoran preemergence may provide adequate control. Envoke applied overtop to soybeans with less than six trifoliate leaves is the most effective option; control may be inadequate once soybean reaches 12". Staple POST typically does not control soybean. However, Staple applied to three- to four-trifoliate soybean followed by a directed application of Caparol, diuron, or Suprend plus MSMA as well as any Envoke mixture may provide adequate control.

Tropical Spiderwort: Prior to Palmer amaranth challenging cotton growers, spiderwort was the most problematic weed of cotton. Current programs implemented to control Palmer amaranth have indirectly controlled spiderwort (Tables 4 and 5). Dual Magnum and Warrant offer the greatest level of residual control in cotton. Gramoxone, glyphosate + Aim, glyphosate + Staple, Direx + MSMA and glyphosate + 2,4-D or dicamba offer the greatest opportunity to control emerged plants. Liberty is not effective; Roundup actually provides better control.

Table 6. Managing Tropical Spiderwort in Roundup Ready Cotton. [1]

Preemergence	POST 1	POST 2	Layby Directed
Warrant[2] + *herbicides appropriate for other weeds*	**Roundup + Staple, Dual Magnum[3] or Warrant[2]** *(Use Staple if spiderwort or Palmer amaranth are up)*	**Roundup + Dual Magnum[3]**	**Direx + MSMA** *(Add Aim if spiderwort is greater than 3 inches; the addition of Dual Magnum[3] or Warrant[2] would improve residual control)*

[1] Deep turning the land will provide fair control of spiderwort.

[2] Apply Warrant no more than twice per season.

[3] Dual Magnum can be applied topically once per crop.

Table 7. Managing Tropical Spiderwort in GlyTol LibertyLink, Enlist Cotton, or XtendFlex Cotton. [1,2]

<table>
<tr><th>Preemergence</th><th>POST 1</th><th>POST 2</th><th>Layby Directed</th></tr>
<tr><td rowspan="2">Warrant[2] + herbicides appropriate for other weeds</td><td>Liberty + Staple, Dual Magnum or Warrant
OR
Roundup + Staple, Dual Magnum or Warrant</td><td>Liberty + Staple, Dual Magnum or Warrant
OR
Roundup + Staple, Dual Magnum or Warrant</td><td rowspan="2">Direx + MSMA
Add Aim if spiderwort is greater than 3 inches; the addition of Dual Magnum or Warrant would improve residual control</td></tr>
<tr><td colspan="2"><u>Considerations for selecting POST 1 and 2 treatments:</u>
1. Use Liberty mixtures if Palmer amaranth has emerged and use Roundup mixtures if Palmer has not emerged.
2. With Liberty or Roundup: add Staple if spiderwort has emerged but use Dual or Warrant if spiderwort has not emerged.</td></tr>
</table>

[1] Deep turning the land will provide fair control of spiderwort.

[1] At time of publication, neither dicamba in tolerant cotton nor 2,4-D in tolerant cotton are labeled. Once labeled these herbicides can be used to effectively control emerged tropical spiderwort.

COTTON WEED CONTROL

A. Stanley Culpepper, Extension Agronomist - Weed Science

WEED	HERBICIDE	MOA	REI/PHI (Hours or Days)	BROADCAST RATE/ACRE		REMARKS AND PRECAUTIONS
				AMOUNT OF FORMULATION	LBS ACTIVE (AI or AE)	
EARLY PREPLANT BURNDOWN						
Burndown of emerged annual weeds but does not adequately control primrose, geranium, large radish, glyphosate-resistant horseweed, or glyphosate-resistant Palmer amaranth.	*glyphosate* 4 S (3 lb ae) 5.4 S (4 lb ae) 5 S (4.17 lb ae) 5.5 S (4.5 lb ae) 6 S (5 lb ae)	9	4 H/ N/A	 32-48 fl oz 24-36 fl oz 23-34 fl oz 22-32 fl oz 19-29 fl oz	0.75-1.13 (lb ae)	Apply any time prior to planting; adjuvant needs vary by brand. ***Control of cover crops:*** Wheat < 12": 0.56 lb ae Wheat > 12": 0.75 lb ae Rye < 12": 0.56 lb ae Rye >12" (no seed head): 0.75 lb ae Rye with seed head: 0.56 lb ae
Emerged primrose, wild radish, spiderwort, very small horseweed.	*2,4-D amine* 4 S 4.7 S 5 S	4	48 H/ N/A	 12-24 fl oz 10-20 fl oz 9-18 fl oz	0.38-0.75	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 mixtures at or near planting. Most, but not all brands, may be applied 30 days prior to planting. PRIMROSE: Apply 0.24-0.38 lb ai/A RADISH: Apply 0.5-0.75 lb ai/A HORSEWEED: Apply 0.75+ lb ai/A GLYPHOSATE-RESISTANT HORSEWEED: Apply 0.95 + lb ai/A
Burndown of most emerged weeds, 2,4-D rates are too low to control glyphosate-resistant horseweed. Mixture may not control Carolina geranium.	*glyphosate* + *2,4-D amine* 4 S 4.7 S 5 S	9 + 4	48 H/ N/A	see glyphosate + 8-32 fl oz 6-24 fl oz 6-22 fl oz	0.75-1.13 (lb ae) + 0.24-0.95	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 primrose and 2,4-D at 0.24 lb ae/A will provide control. For glyphosate-resistant horseweed the rate of 0.95 lb ai/A will control small plants. 2,4-D is more effective than dicamba on primrose; less effective on horseweed. Use amine formulations of 2,4-D to reduce potential for off-target movement; no differences in control compared to other formulations when mixed with glyphosate. ***2,4-D volatility occurs and is influenced by environment, soil conditions, and formulations used; avoid off-target issues.***
Aim improves control of emerged morningglory, tropical spiderwort, and very small (<1") glyphosate-resistant Palmer amaranth.	*glyphosate* + *carfentrazone* Aim 2 EC	9 + 14	12 H/ N/A	see glyphosate + 0.5-1.0 fl oz	0.75-1.13 (lb ae) + 0.008-0.016	May be applied as a burndown treatment any time prior to planting. Aim does not provide residual weed control.

WEED	HERBICIDE	MOA	REI/PHI (Hours or Days)	BROADCAST RATE/ACRE		REMARKS AND PRECAUTIONS
				AMOUNT OF FORMULATION	LBS ACTIVE (AI or AE)	
EARLY PREPLANT BURNDOWN (continued)						
Dicamba improves primrose, morningglory, and glyphosate-resistant horseweed control. Suppresses geranium and curly dock. At this rate, likely will not control Palmer amaranth larger than 1.5".	*glyphosate* + *dicamba* Clarity, other 4S	9 + 4	24 H/ N/A	see glyphosate + 8 fl oz	0.75-1.13 (lb ae) + 0.25	Following application of dicamba AND a minimum of 1" 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 and wild radish; but more effective on horseweed. Numerous formulations of dicamba exist. ***Dicamba volatility occurs and is influenced by environmental conditions, soil types, and formulations selected; avoid off-target issues.***
Diuron improves control of emerged Palmer amaranth and provides residual control if it reaches the ground and is activated. The addition of 2,4-D or Valor will likely improve weed control; follow most restrictive plant-back interval.	*glyphosate* + *diuron* Direx 4F	9 +7	12 H/ N/A	see glyphosate + 1-1.5 pt	0.75-1.13 (lb ae) + 0.5-0.75	A Georgia 24 C Direx label allows applications up to the day ahead of planting if strip tillage implement is run between application and planting. If no tillage occurs between application and planting then one should wait at least 10 days prior to planting. Do not apply on sand or loamy sand soils. If following shortened plant-back interval, suggest avoid using diuron again PRE. **Many diuron formulations are available but have longer plant-back interval, see labels.**
Valor improves emerged primrose and radish control. Valor also provides residual control of pigweed, pusley, smallflower morningglory and other sensitive weeds for up to 6-8 weeks if it reaches the soil and is activated. The addition of 2,4-D (8-16 oz/A of 3.8 lb ai material) would improve control of radish and primrose; follow most restrictive plant-back interval. ***For PPO-resistance management, make only 3 applications of Reflex or Valor (including generics) on a field in 3 years.***	*glyphosate* + *flumioxazin* Valor SX 51 WDG	9 + 14	12 H/ N/A	see glyphosate + 2 oz	0.75-1.13 (lb ae) + 0.063	A Georgia 24 c Valor label allows reduced plant-back intervals and provides safer use patterns for Valor in cotton. Outflank, Panther, and Rowel have been tested and perform similarly to Valor but do not have the state label allowing the following use patterns: **In strip-till cotton,** Valor can be applied 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. Valor plant-back interval should be as follows: 1) <30% ground cover wait 28 days PLUS 1" of rain; 2) >30% ground cover wait 21 days PLUS 1" of rain. ***If Reflex (or generic) will be applied PRE; suggest adding an additional 7 days to no-tillage and 4 days to strip-tillage planting intervals.*** Add a non-ionic surfactant or crop oil concentrate (preferred), regardless of glyphosate brand. **CAREFULLY follow label directions for cleaning sprayer after each use!**
ET improves control of emerged morningglory and small (< 1") glyphosate-resistant Palmer amaranth.	*glyphosate* + *pyraflufen ethyl* ET 0.208 EC	9 + 14	12 H/ N/A	see glyphosate + 0.5-2 fl oz	0.75-1.13 (lb ae) + 0.0008-0.003	May be applied as a burndown treatment anytime prior to planting. ET does not provide residual weed control.

WEED	HERBICIDE	MOA	REI/PHI (Hours or Days)	BROADCAST RATE/ACRE		REMARKS AND PRECAUTIONS
				AMOUNT OF FORMULATION	LBS ACTIVE (AI or AE)	
EARLY PREPLANT BURNDOWN (continued)						
Improved control of henbit, chickweed, Carolina geranium, 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. Dicamba and 2,4-D are more effective on horseweed. Valor and diuron are more effective providing residual control.	*glyphosate* + *thifensulfuron + tribenuron* FirstShot SG 50 SG	9 + 14	12 H/ N/A	see glyphosate + 0.5-0.8 oz	0.75-1.13 (lb ae) + 0.008-0.013 + 0.008-0.013	Apply at least 14 days prior to planting. Include nonionic surfactant at 1-2 qt per 100 gal spray or crop oil concentrate at 1-2 gal per 100 gal spray.
	glyphosate + *thifensulfuron + tribenuron* Harmony Extra SG with TotalSol 50 SG Harmony Extra, Nimble 75WDG	9 + 2 + 2	12 H/ N/A	see glyphosate + 0.75 oz 0.5 oz	0.75-1.13 (lb ae) + 0.0156 + 0.0078	
Burndown of emerged annual weeds; best control with annual weeds 3" or less. Does not control immature primrose, large horseweed, curly dock, swinecress, immature radish, or large grasses. Mixtures with diuron are usually far more effective.	*paraquat* Gramoxone 2S Firestorm, Parazone 3S	22	24 H/ N/A	2.5-4 pt 1.7-2.7 pt	0.63-1	Apply any time prior to planting to control emerged weeds. Add nonionic surfactant at 2 pt/100 gal of spray mix or crop oil concentrate at 1 gal/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. Gramoxone, Firestorm, and Parazone have been tested; however, numerous other brands of paraquat are also available, see labels.
Burndown of emerged annual weeds and provides residual control if diuron reaches the soil and is activated. Effective on mature primrose and wild radish. BY FAR the most effective option for emerged pigweed. Option for emerged glyphosate-resistant pigweed. If extended residual control is desired, consider adding Valor to the mixture.	*paraquat* Gramoxone 2S Firestorm, Parazone 3S + *diuron* Direx 4F	22 + 7	24 H/ N/A	2.5-4 pt 1.7-2.7 pt + 1.5-2 pt	0.63-1 + 0.75-1	A Georgia 24(c) Direx label allows applications up to the day ahead of planting if a strip-tillage implement is run between Direx applica- tion and planting. If no tillage occurs between Direx application and planting then one should wait at least 10 days prior to planting. Do not apply on sand or loamy sand soil. If following shortened plant-back interval, suggest avoid using diuron again PRE. **Add crop oil concentrate at 1 gal/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.

WEED	HERBICIDE	MOA	REI/PHI (Hours or Days)	BROADCAST RATE/ACRE		REMARKS AND PRECAUTIONS
				AMOUNT OF FORMULATION	LBS ACTIVE (AI or AE)	
EARLY PREPLANT BURNDOWN (continued)						
Paraquat mixtures with diuron are more effective on emerged Palmer amaranth; however, Valor is more effective in providing residual Palmer amaranth control. The addition of diuron is suggested if pigweed is larger than 3". ***For PPO-resistance management, make only 3 applications of Valor or Reflex (including generics) on a field in 3 years.***	*paraquat* Gramoxone 2 SL Firestorm, Parazone 3 SL + *flumioxazin* Valor SX 51 WDG	22 + 14	12 H/ N/A	 2.5-4 pt 1.7-2.7 pt + 2 oz	0.63-1 + 0.063	A Georgia 24 c Valor label allows reduced plant-back intervals and provides safer use patterns for Valor in cotton. Outflank, Panther, and Rowel have been tested and perform similarly to Valor but do not have the state label allowing the following use patterns: **In strip-till cotton**, Valor can be applied 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. Valor plant-back interval should be as follows: 1) <30% ground cover wait 28 days PLUS 1" of rain; 2) >30% ground cover wait 21 days PLUS 1" of rain. ***If Reflex (or generic) will be applied PRE; suggest an additional 7 days to no-tillage and 4 days to strip-till planting intervals.*** Add a non-ionic surfactant or crop oil concentrate (preferred). **Carefully follow label directions for cleaning sprayer after each use!!**
Winter annual broadleaf weeds such as henbit, chickweed, small wild radish, and curly dock. DO NOT anticipate residual control for Palmer amaranth.	*rimsulfuron* + *thifensulfuron* Leadoff 33 SG	2 + 2	4 H/ N/A	 1.5 oz	0.0156 + 0.0156	Apply at least 30 days prior to planting. Can increase rate to 2 oz/A if applying at least 60 days prior to planting. Also suggest at least 1 inch of rain accumulation prior to planting. Mixing 2,4-D with Leadoff will improve control of problematic weeds such as radish, primrose, and horseweed. May also mix with glyphosate for improved control of numerous weed species.
EARLY PREPLANT BURNDOWN OF GLYPHOSATE-RESISTANT HORSEWEED						
Glyphosate-resistant horseweed is becoming more common across Georgia. Research from other states suggests dicamba may be more effective than 2,4-D on larger horseweeds. Applications should be made prior to April for maximum timeliness. ***For PPO-resistance management, make only 3 applications of Valor or Reflex (or generics) on a field in 3 years.***	*glyphosate* + *2,4-D amine* numerous brands + *flumioxazin* Valor SX, other 51 WDG	9 + 4 + 14	48 H/ N/A	see glyphosate + see label + 2 oz	0.75-1.13 (lb ae) + 0.95 (lb ae) + 0.063	Glyphosate plus 2,4-D plus Valor SX, or glyphosate plus dicamba plus Valor are the **preferred treatments.** See sections above on plant back intervals. The 2,4-D or dicamba is needed in the mixture to control emerged resistant horseweed while the Valor provides residual control for seeds that may germinate after the application.
	glyphosate + *dicamba* Clarity, other 4 SL + *flumioxazin* Valor SX, other 51 WDG	9 + 4 + 14	24 H/ N/A	see glyphosate + 8 fl oz + 2 oz	0.75-1.13 (lb ae) + 0.25 + 0.063	**Carefully follow label directions for cleaning sprayer after each use!** Clarity is formulated as a diglycolamine salt of dicamba which is preferred over the dimethylamine salt. Other brands of flumioxazin are also available including Outflank, Panther, and Rowel; however, these products do not have the same plant-back intervals as Valor, see label. ***2,4-D and dicamba volatility occurs and is influenced by environmental conditions, soil types, and formulations selected; avoid off-target issues.***

WEED	HERBICIDE	MOA	REI/PHI (Hours or Days)	BROADCAST RATE/ACRE		REMARKS AND PRECAUTIONS
				AMOUNT OF FORMULATION	LBS ACTIVE (AI or AE)	
EARLY PREPLANT BURNDOWN OF GLYPHOSATE-RESISTANT HORSEWEED (continued)						
Glyphosate-resistant horseweed (continued)	*paraquat* Gramoxone Inteon 2S Firestorm, Parazone 3S + *diuron* Direx 4 F	22 + 7	24 H/ N/A	4 pt 2.7 pt + 1.5-2 pt	1 + 0.75-1	A Georgia 24(c) Direx label allows applications up to the day ahead of planting if a strip-tillage implement is run between Direx application and planting. If no tillage occurs between Direx application and planting then one should wait at least 10 days prior to planting. Do not apply on sand or loamy sand soil. Suggest avoiding diuron PRE if following shortened plant-back interval. Spray when daytime temps exceed 70°F. Add 1 gal of crop oil concentrate/100 gal of spray mix. May add 2,4-D or dicamba to improve control of emerged plants; follow proper plant-back intervals.
For resistance management, do not apply glufosinate on a field more than 2 times a year.	*glufosinate* Liberty 2.34 S	10	12 H/ N/A	29-43 fl oz	0.53-0.79	Recommended for fields where growers have failed to control glypho-sate- resistant horseweed and it is too late for 2,4-D or dicamba. If greater than 29 oz/A is applied preplant, the season total applied cannot exceed 72 fl oz/A. ***To maximize control:*** >15 GPA water volume, medium spray droplet, warm temperatures, high humidity, bright sunlight, good soil moisture, and do not spray within 1.5 hours of sunrise or 1 hour of sunset. Cheetah and Interline have been tested and performed similarly to Liberty, see labels. Other brands are available.
PREPLANT: AT OR JUST PRIOR TO PLANTING						
Burndown of emerged annual weeds and cover crops. Inadequate control of primrose, radish, geranium and resistant pigweed or horseweed often noted.	*glyphosate* 4S (3 lb ae) 5.4S (4 lb ae) 5S (4.17 lb ae) 5.5S (4.5 lb ae) 6S (5 lb ae)	9	4 H/ N/A	32-48 fl oz 24-36 fl oz 23-34 fl oz 22-32 fl oz 11-29 fl oz	0.75-1.13 (lb ae)	***If Palmer is emerged at time of planting, better control with paraquat is most often achieved with applications prior to planting as the planting process may cover them with dirt.*** Add nonionic surfactant at 2 pt/100 gal or crop oil concentrate at 1 gal/100 gal spray mix for paraquat. Need for adjuvants with glyphosate depend upon brand used. **<u>Control of mature cover crops with seedheads:</u>** Wheat < 12": glyphosate 0.75 lb ae or paraquat 0.63 lb Wheat > 12": glyphosate 0.75 lb ae or paraquat 0.75 lb Rye < 18": glyphosate 0.56 lb ae or paraquat 0.6 lb Rye > 18": glyphosate 0.75 lb ae or paraquat 0.75 lb Rye with seed head: 0.56 lb ae
Burndown of emerged annual weeds. Does not control immature primrose, large horse-weed, curly dock, swinecress, immature radish, or large grasses or pigweeds over 3".	*paraquat* Gramoxone 2S Firestorm, Parazone 3S	22	24 H/ N/A	2.5-4 pt 1.7-2.7 pt	0.63-1	
Burndown of mature primrose and morningglory. Inadequate control of immature radish, pigweeds over 3" or grain cover crops. ***For resistance management, do not apply glufosinate on a field more than 2 times a year.***	*glufosinate* Liberty 2.34S	10	12 H/ N/A	29-43 fl oz	0.53-0.79	Applications can be made prior to cotton emergence. ***To maximize control:*** >15 GPA water volume, medium spray droplet, warm temperatures, high humidity, bright sunlight, good soil moisture, and do not spray within 1.5 hours of sunrise or 1 hour of sunset. **For Palmer amaranth, apply 29 oz/A when less than 3"; 32 oz/A when 3"; 36 oz/A when 4"; and 43 oz/A when taller than 4".** Cheetah, and Interline have been tested and performed similarly to Liberty, see labels. Other brands are available.

WEED	HERBICIDE	MOA	REI/PHI (Hours or Days)	BROADCAST RATE/ACRE		REMARKS AND PRECAUTIONS
				AMOUNT OF FORMULATION	LBS ACTIVE (AI or AE)	
PREPLANT INCORPORATED						
Annual grasses, pigweeds and Florida pusley. Controls glyphosate-resistant Palmer amaranth much more effectively than when applied preemergence.	*pendimethalin* Prowl 3.3 EC Prowl H20 3.8 AS	3	24 H/ N/A	1.2-2.4 pt 2 pt	0.5-1 0.95	Soil incorporate in top 2" of the soil within 24 hours of application; consider mixing with Reflex. Application and incorporation 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 control. For Treflan 4 L, rate should not exceed 1.5 pt/A for most fields. The need for a PRE herbicide as noted with the split program below is critical.
	trifluralin Treflan, others 4 EC	3	12 H/ N/A	1-2 pt	0.5-1	
Glyphosate-resistant Palmer amaranth and yellow nutsedge ***For PPO-resistance management, make only 3 applications of Valor or Reflex (including generics) on a field in 3 years.***	*fomesafen* Reflex 2S	14	24 H/ N/A	16 fl oz	0.25	A Georgia Section 2 (ee) Reflex label allows a preplant application by incorporating Reflex to a SHALLOW (2" or less) depth while the soil is moist; suggest including pendimethalin or trifurualin. The need for a PRE herbicide as noted with the split program below is critical; ***reduce Reflex rate accordingly if implementing split PPI and PRE program.*** For Palmer amaranth, less control is noted with Reflex alone incorporated when compared to preemergence applications if activated immediately by rainfall or irrigation; less injury potential is also noted with incorporated application. Thus the split program, below, is usually the best option.
SPLIT PROGRAM WITH PREPLANT INCORPORATED (PPI) FOLLOWED BY PREEMERGENCE (PRE) APPLICATIONS						
The SINGLE MOST effective approach for the control of Palmer amaranth while also offering the least injury potential from fomesafen. Very beneficial on dryland production. ***For PPO-resistance management, make only 3 applications of Valor or Reflex (including generics) on a field in 3 years.***	**PPI:**					PPI: Shallow (2") incorporation is required. Plant within 1 week of application and incorporation if possible. Numerous formulations of fomesafen are available; however, they may not support this use pattern, see label.
	trifluralin or pendimethalin + *fomesafen* Reflex 2S		24 H/ N/A	See rates in preplant incorporated + 10-12 oz	See rates in preplant incorporated + 0.16-0.19	
	PRE:					PRE: 1. Be sure to include paraquat PRE if glyphosate-resistant Palmer amaranth is emerged. 2. Warrant offers greater residual control when compared to diuron while diuron offers greater control of emerged weeds. 3. If mixing Reflex + Warrant + diuron, the rate of diuron for most fields should not exceed 10 oz/A. Numerous formulations of fomesafen and diuron are available; see label.
	fomesafen Reflex 2S + *acetochlor* Warrant 3ME <u>OR</u> *diuron* Direx, diuron 4F	3 + 14 + 15 or 7	24 H/ N/A	8-10 oz + 32 fl oz <u>OR</u> 10-20 fl oz	0.125-0.16 + 0.75 <u>OR</u> 0.31-0.63	

WEED	HERBICIDE	MOA	REI/PHI (Hours or Days)	BROADCAST RATE/ACRE		REMARKS AND PRECAUTIONS
				AMOUNT OF FORMULATION	LBS ACTIVE (AI or AE)	
PREEMERGENCE-BROADLEAF AND GRASS CONTROL						
Residual control of annual grasses, Palmer amaranth, and tropical spiderwort.	*acetochlor* Warrant 3 ME	15	12 H/ N/A	2-3 pt	0.75-1.125	Warrant should be applied in combination with fomesafen (Reflex, others), diuron, or Cotoran depending on Palmer population and technology grown; add paraquat and adjuvant if Palmer is up. Apply within 24 hr of planting. A rate of 2-2.5 pt/A is in order when 1) tank mixing with another effective residual herbicide, 2) applying on light soil textures, and/or 3) using intense irrigation during the first 2 wk of planting.
Residual control of many annual grasses and broadleaves including Palmer amaranth and tropical spiderwort; suppression of yellow nutsedge.	*acetochlor + fomesafen* Warrant Ultra 3.45 CS	15 + 14	24 H/ N/A	2.4 pt	0.84 + 0.19	Apply within 24 hr of planting; add paraquat plus adjuvant if Palmer is up. Warrant Ultra at 2.4 pt/A provides 2.2 pt of Warrant and 0.19 lb ai of fomesafen (equivalent to 12 oz/A of Reflex). This rate is ideal for lighter soil textures, under intense irrigation, and when used in dicamba- or 2,4-D-based programs. On heavier soils when implementing Roundup- or Liberty-based programs, the addition of Warrant at 0.5 pt/A to this mix may be in order.
Residual suppression of annual broadleaf weeds and grasses. More effective than Cotoran on pigweed, less effective on most other weeds.	*diuron* Direx, others 80 DF Direx, others 4L	7	12 H/ N/A	0.38-0.78 lb 10-20 fl oz	0.31-0.62	Diuron should be applied in combination with fomesafen (Reflex, others) or Warrant depending on Palmer population and technology grown; add paraquat and adjuvant if Palmer is up. Apply within 24 hr of planting. See label for specific rate on soils; in general lower rate on sandier soils and/or intense irrigation. Label restricts use on sands or soils with < 1% organic matter.
Residual suppression of broadleaf weeds and grasses. Most effective residual material for sicklepod, cocklebur, and morningglory control. Less effective than diuron on Palmer amaranth.	*fluometuron* Cotoran 4F	7	12 H/ N/A	2-3 pt	1-1.5	Cotoran should be applied in combination with fomesafen (Reflex, others) or Warrant depending on Palmer population and technology grown; add paraquat and adjuvant if Palmer is up. Apply within 24 hr of planting. See label for specific rate on soils but in general lower rate on sandier soils and/or intense irrigation. A maximum of 2 pt/A is ideal for most GA soils.
Excellent residual control of Palmer amaranth if activated. New herbicide chemistry for a cotton grower.	*fluridone + fomesafen* Brake F16	12+14	24 H/ N/A	16 fl oz	0.15 + 0.1875	Contains fluridone plus the equivalent of 0.1875 lbs of fomesafen which would equal 12 oz of Reflex. Although the fomesafen requires around 0.3" rainfall/irrigation for activation, fluridone requires a minimum of 0.5" rainfall/irrigation. Carryover to small grains and soybeans 8 mo; sorghum, peanut, corn 10 mo; tobacco and most veggies at least 18 mo.
The most effective residual herbicide for the control of glyphosate-resistant Palmer amaranth. Good control of poinsettia and suppression of yellow nutsedge. ***For PPO resistance manage-ment, make only 3 applications of fomesafen or Valor (including generics) on a field in 3 years.***	*fomesafen* Reflex, Dawn 2S	14	24 H/ N/A	12-16 fl oz	0.19-0.25	Reflex or generics should be applied in combination with Warrant, diuron, or Cotoran for maximum control depending on Palmer population and technology grown; add paraquat and adjuvant if Palmer is up. Apply within 24 hr of planting. ***Research suggests 12 oz/A is an appropriate rate when mixed with Warrant or diuron on most soils***. Apply only to coarse-textured soils; however on sandy soils with low organic matter use lower rates. Injury more often occurs when initial rains or irrigation occur as cotton is emerging; follow irrigation program on the 2017 Palmer Circular. Fomesafen provides good residual pigweed control even if the first rain does not occur until 15 days after treatment. Pigweed that emerges before activation will not be controlled.
Annual grasses and Florida pusley; suppression of Palmer amaranth only. Irrigation or rain-fall needed within 24 hours.	*pendimethalin* Prowl 3.3 EC Prowl H20 3.8 AS	3	24 H/ N/A	1.8-3.6 pt 2-3 pt	0.75-1.5 0.95-1.42	Preemergence applications are far less consistent than incorporated treatments; tank mixtures are needed. Wet/moist conditions during emergence (rainfall or irrigation) can cause significant plant stunting, leaf/stem malformation, and stem swelling with eventual breaking; especially if used in combination with Reflex (generic). Apply within 24 hours of planting.

WEED	HERBICIDE	MOA	REI/PHI (Hours or Days)	BROADCAST RATE/ACRE		REMARKS AND PRECAUTIONS
				AMOUNT OF FORMULATION	LBS ACTIVE (AI or AE)	
PREEMERGENCE-BROADLEAF AND GRASS CONTROL (continued)						
Controls non-ALS resistant pigweeds, lambsquarters, prickly sida, spurge, and smartweed. Suppresses morningglory, except tall. ***Make only 1 timely application of Staple and/or Envoke per season.***	*pyrithiobac* Staple LX, Pyrimax 3.2S	2	4 H/ N/A	1.7-2.1 fl oz	0.0425-0.053	Staple or Pyrimax are excellent residual herbicides but cotton injury, especially on irrigated light textured soils is a serious concern. Thus, a delayed PRE or early POST use of Staple is being recommended by UGA; contact your local Extension office for a circular or go to gaweed.com. Do not apply on soils with less than 0.5% organic matter. Can tank mix with diuron, fluometuron, pendimethalin, or Reflex; apply within 24 hr of planting. The addition of paraquat or glyphosate is needed if weeds are emerged.
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.						
Pigweed less than 1", morningglory (excluding tall mg), coffee senna, and redweed. Suppresses sicklepod and will not control ALS-resistant pigweed. Provides good residual control of many species if reaches the ground and is activated. ***Make only 1 TIMELY application of Staple and/or Envoke per season.***	*pyrithiobac* Staple LX, Pyrimax 3.2S	2	4 H/ 60 days	2.7-3 fl oz	0.06-0.07	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. Label also allows increasing rate of an application to 3.8 fl oz but injury is a concern. Residual control of non-ALS resistant Palmer has been good even if the first activating rain does not occur for 15 days after application, plants emerging before activation will not be controlled. Do not mix with grass control herbicides. May mix with most insecticides, but do not tank mix with any product containing malathion. **Do not mix with any Dual product or Warrant.** Separate Staple and Dual/Warrant applications by 5 or more days. See label for rotational restrictions.
Annual broadleaf weeds including sicklepod, *Ipomoea* morningglory, and nutsedge. Will not control smallflower morningglory or ALS-resistant pigweed, jimsonweed, copperleaf, or prickly sida. ***Make only 1 TIMELY application of Staple and/or Envoke per season.***	*trifloxysulfuron* Envoke 75 WDG	2	12 H/ 60 D	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 and less injury. Add nonionic surfactant at 1 qt/100 gal; do not use other types of adjuvants. Do not mix with other pesticides including plant growth regulators. In an attempt to avoid injury, do not apply to cotton under stress, such as very dry, wet, or cool conditions. Envoke may be directed to cotton 6" or larger at rates of 0.1-0.25 oz/A. See label for details and rotational restrictions. Rain fast in 3 hr. **Also provides residual control of sensitive species if contacts soil and is activated.**
Most broadleaf weeds. Poor control of tropic croton, copperleaf and ALS-resistant pigweed. Good residual if activated.	*trifloxysulfuron* Envoke 75 WDG + *pyrithiobac* Staple LX 3.2 SL	2 + 2	12 H/ 60 D	0.1 oz + 1.3-1.9 fl oz	0.0047 + 0.03-0.05	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/100 gal spray mix. See comments and restrictions for each product 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	MOA	REI/PHI (Hours or Days)	BROADCAST RATE/ACRE		REMARKS AND PRECAUTIONS
				AMOUNT OF FORMULATION	LBS ACTIVE (AI or AE)	
POSTEMERGENCE OVER-THE-TOP BROADLEAF AND GRASS CONTROL FOR CULTIVARS TOLERANT TO GLUFOSINATE (LIBERTY, ETC.) **Application of postemergence herbicide treatments to moisture stressed weeds usually results in poor control.**						
An at-plant residual herbicide should always be used in a Liberty system. Control of pusley, spiderwort, and goosegrass are not consistent. In general, broadleaf weeds should be <3" and grasses < 2". Excellent control of morningglory including moonflower. **For Palmer amaranth, apply 29 oz/A when less than 3"; 32 oz/A when 3"; 36 oz/A when 4"; and 43 oz/A when taller than 4".** ***For resistance management, do not make more than 2 applications of glufosinate per year on a field; include two herbicides PRE, residual mixtures POST, and a directed layby.***	*glufosinate* Liberty 2.34 S	10	12 H/ 70 D	 29-43 fl oz	0.53-0.79	**Cotton tolerant to glufosinate (Liberty, etc.).** Label allows application from full cotyledonary cotton through early bloom; however, UGA recommends applications after 8 leaf cotton be sloppy directed to reduce injury potential while improving weed control. Do not exceed 43 fl oz/A per application. Also, do not exceed 87 fl oz/A per season with individual applications of 29 fl oz/A or less, and do not exceed 72 oz/A per season if any individual application greater than 29 oz/A is made. ***To maximize control:*** >15 GPA water volume, medium spray droplet, warm temperatures, high humidity, bright sunlight, good soil moisture, and do not spray within 1.5 hours of sunrise or 1 hour of sunset. Mixtures with residual herbicides are usually needed to assist in the control of grasses, pusley, spiderwort, and pigweed. Cheetah and Interline are formulations of glufosinate that have been tested; other brands are available. Research has shown in some environments, especially saturated soils, that more injury from Liberty is observed with XTENDFLEX cotton compared to LibertyLink cotton; however, injury with XtendFlex cotton is less than that of Widestrike cotton. Rain fast within 4 hours. Do not tank mix with grass herbicides.
Staple may improve emerged pigweed control (non ALS-resistant) and provides residual activity on sensitive weeds if spray contacts soil and is activated. ***For resistance management, do not make more than 2 applications of glufosinate per year in a field; include 2 herbicides PRE and a directed layby. Also do not make more than 1 Staple and/or Envoke application per year in a field.***	*glufosinate* Liberty 2.34 S + *pyrithiobac* Staple LX 3.2 SL	10 + 2	12 H/ 70 D	29 fl oz + 1.9 fl oz	0.53-0.58 + 0.03-0.05	**Cotton tolerant to glufosinate (Liberty, etc.).** See information for glufosinate alone just above. Leaf speckling/burn/chlorosis will occur. Avoid dew, extremely high temperatures, saturated soils, and mixtures with other pesticides or adjuvants to reduce injury potential. Do not mix with any metolachlor (Dual) product or Warrant. Cheetah and Interline are formulations of glufosinate that have been tested; other brands are available. Research has shown in some environments, especially saturated soils, that more injury from Liberty is observed with XtendFlex cotton compared to LibertyLink cotton; however, injury with XtendFlex cotton is less than that of Widestrike cotton.

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

WEED	HERBICIDE	MOA	REI/PHI (Hours or Days)	BROADCAST RATE/ACRE		REMARKS AND PRECAUTIONS
				AMOUNT OF FORMULATION	LBS ACTIVE (AI or AE)	
POSTEMERGENCE OVER-THE-TOP BROADLEAF AND GRASS CONTROL FOR CULTIVARS TOLERANT TO GLUFOSINATE (LIBERTY, ETC.) (continued) Application of postemergence herbicide treatments to moisture stressed weeds usually results in poor control.						
Dual or Warrant provides residual control of grasses, spiderwort, and pigweeds if spray contacts soil and is activated. Outlook provides residual control of grasses and pigweeds; spiderwort has not been studied. Comparing Dual and Warrant, Dual activity begins more quickly with immediate activation while Warrant is more stable waiting on activation. **For Palmer amaranth, apply Liberty at 29 oz/A when less than 3"; 32 oz/A when 3"; 36 oz/A when 4"; and 43 oz/A when taller than 4".** ***For resistance management, do not make more than 2 applications of glufosinate per year in a field; include 2herbicides PRE and a directed layby.***	*glufosinate* Liberty 2.34 S + *acetochlor* Warrant 3 ME	10 + 15	24 H/ 70 D	29-43 fl oz + 2-3 pt	0.53-0.79 + 0.75-1.125	**Cotton tolerant to glufosinate (Liberty, etc.).** ***Warrant*** mixture can be applied from cotton being fully emerged through early bloom. ***Dual Magnum*** mixture can be applied from cotton being fully emerged through 100 days before harvest if applied overtop, up to 80 days before harvest if directed or early bloom, whichever is more restrictive. ***Outlook*** mixture can be applied from 1-leaf cotton through second week of bloom. ***UGA research strongly encourages these mixtures to be directed after 8-leaf cotton for reduced injury and better weed control.*** Some leaf speckling/burn will likely occur. Injury may be enhanced if applied to cotton with dew, under extremely high temperatures, saturated soils, or when mixed with insecticides or adjuvants. Research has shown in some environments, especially saturated soils, that more injury from Liberty is observed with XtendFlex cotton compared to LibertyLink cotton; however, injury with XtendFlex Cotton is less than that of widestrike cotton. Cotton usually recovers rapidly. ***To maximize control:*** >15 GPA water volume, medium spray droplet, warm temperatures, high humidity, bright sunlight, good soil moisture, and do not spray within 1.5 hours of sunrise or 1 hour of sunset. Several products containing metolachlor (not S-metolachlor) are available. Metolachlor products are less effective per unit of formulated product than those with S-metolachlor. In general it takes 1.5 pt of a metolachlor product to give the activity one gets from 1 pt of S-metolachlor. Cheetah and Interline are available formulations of glufosinate that have been tested; other brands are available.
	glufosinate Liberty 2.34 S + *S-metolachlor* Dual Magnum 7.62 EC	10 + 15	24 H/ 80 D	29-43 fl oz + 1 pt	0.53-0.79 + 0.95	
	glufosinate Liberty 2.34 S + *dimethenamid-P* Outlook 6 EC	10 + 15	12 H/ N/A	29-43 fl oz + 12-16 fl oz	0.53-0.79 + 0.56-0.75	
POSTEMERGENCE OVER-THE-TOP BROADLEAF AND GRASS CONTROL IN PHYTOGEN WIDESTRIKE COTTON Application of postemergence herbicide treatments to moisture stressed weeds usually result in poor control.						
Glyphosate-resistant Palmer amaranth in Widestrike cotton. ***For resistance management, do not make more than 2 applications of glufosinate per year in a field; include 2 herbicides PRE and a directed layby.***	*glufosinate* Liberty 280SL 2.34S	10	12 H/ 70 D	29 fl oz	0.53	Phytogen cultivars with the Widestrike trait are tolerant to Liberty. Tolerance in these cultivars is not complete, and varying levels of crop injury are often noted. Greater injury can be expected when Liberty 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 the second application being made no later than 8 leaf cotton. See above comments for use of Liberty in Liberty Link cotton, including statement on application time of day.

WEED	HERBICIDE	MOA	REI/PHI (Hours or Days)	BROADCAST RATE/ACRE		REMARKS AND PRECAUTIONS
				AMOUNT OF FORMULATION	LBS ACTIVE (AI or AE)	
POSTEMERGENCE OVER-THE-TOP BROADLEAF AND GRASS CONTROL FOR CULTIVARS TOLERANT TO GLYPHOSATE (ROUNDUP, ETC.) **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. ***Never apply glyphosate alone. Obtain sound management programs from your Extension office or at gaweed.com.***	*glyphosate* 4S (3 lb ae) 5.4S (4 lb ae) 5S (4.17 lb ae) 5.5S (4.5 lb ae) 6S (5 lb ae)	9	4 H/ 7 D	 32-48 oz 24-36 oz 23-34 oz 22-32 oz 19-29 oz	0.75-1.12 (lb ae)	**Cultivar must be tolerant to glyphosate (Roundup, etc.).** WeatherMax or PowerMax (4.5 lb ae) 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 ae). Do not exceed a total of 128 fl oz (4.5 lb ae) applied from emergence through 60% open bolls. Do not exceed a maximum of 44 fl oz (1.55 lb ae) 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. **A glyphosate-based program should include: 1) no weeds emerged at planting; 2) two residual herbicides at planting; 3) residual herbicides with Roundup POST and a conventional directed layby.**
Warrant provides residual control of grasses, pigweeds and tropical spiderwort, if the acetochlor contacts the soil and is activated.	*glyphosate* + *acetochlor* Warrant 3 ME	9 + 15	12 H/ do not apply after bloom	see glyphosate + 2-3 pts	0.75-1.12 + 0.75-1.125	**Cultivar must be tolerant to glyphosate (Roundup, etc.).** See comments for glyphosate alone. Label allows a topical application once cotton is completely emerged until it reaches bloom; however, UGA research suggests making directed applications after the 8-leaf stage to reduce injury potential while improving weed control. A topical and directed application may be made as long as Warrant was not applied PRE; if Warrant was applied PRE then one POST application can be made. Use loaded glyphosate formulation; do not add adjuvants or other pesticides including Staple. Avoid heavy dew on cotton plant, saturated soils, and extreme, hot conditions.
Outlook provides residual control of annual grasses and pigweeds if it reaches the soil and is activated; no current data on spiderwort.	*glyphosate* + *dimethenamid-P* Outlook 6 EC	9 + 15	12 H/ N/A	see glyphosate + 12-16 fl oz	0.75-1.12 + 0.56-0.75	**Cultivar must be tolerant to glyphosate (Roundup, etc.).** See comments for glyphosate alone. Label allows a topical application from 1-leaf cotton through 2nd week of bloom; however, UGA research suggests making directed applications after the 8-leaf stage to reduce injury potential while improving weed control. Only one application of Outlook per year. Suggested rate is 12 oz/A on coarse soils or under intense irrigation. Some leaf speckling/burn will likely occur. Avoid heavy dew on cotton plant, saturated soils, and extreme, hot conditions.

WEED	HERBICIDE	MOA	REI/PHI (Hours or Days)	BROADCAST RATE/ACRE		REMARKS AND PRECAUTIONS
				AMOUNT OF FORMULATION	LBS ACTIVE (AI or AE)	
POSTEMERGENCE OVER-THE-TOP BROADLEAF AND GRASS CONTROL FOR CULTIVARS TOLERANT TO GLYPHOSATE (ROUNDUP, ETC.) Application of postemergence herbicide treatments to moisture stressed weeds usually results in poor control. (continued)						
Staple improves control of hemp sesbania, morningglory, tropical spiderwort, and glyphosate-resistant Palmer amaranth. Staple will provide residual control of pigweeds, prickly sida, smartweed, spurred anoda, and velvetleaf if it contacts the soil and is activated. **Will not control ALS + glyphosate resistant Palmer.**	*glyphosate* + *pyrithiobac* Staple LX, Pyrimax 3.2SL	9 + 2	4 H/ 60 D	see glyphosate + 2-3 fl oz	0.75-1.12 + 0.05-0.07	**Cultivar must be tolerant to glyphosate (Roundup, etc.).** See comments for glyphosate and Staple alone. Apply overtop from cotton cotyledonary stage until 60 days prior to harvest, however, UGA research suggests making directed applications after the 8-leaf stage to reduce injury potential while improving weed control. Some leaf speckling/burn will likely occur. Avoid heavy dew on cotton plant, saturated soils, and extreme, hot conditions. Do not mix with any Dual/metolachlor products or Warrant. For Palmer amaranth, apply Staple at 2.5-3 oz/A when Palmer is 2" or less; rate can be increased to 3.8 oz/A but injury is a concern. For residual control, a rate of 1.9-2.1 oz/A should perform very well. **Make only 1 TIMELY application of Staple and/or Envoke per season.**
Metolachlor controls annual grasses, pigweeds, doveweed, Florida pusley, tropical spiderwort and suppresses yellow nutsedge if it contacts the soil and is activated. Several products containing metolachlor (not S-metolachlor) are available and labeled. Metolachlor products are less effective per unit of formulated product than those with S-metolachlor. In general it takes 1.5 pt of a metolachlor product to give the activity one gets from 1 pt of S-metolachlor.	*glyphosate* + *S-metolachlor* Dual Magnum 7.62 EC Brawl 7.62 EC	9 + 15	24 H/ 100 D	see glyphosate + 1 pt 1 pt	0.75-1.12 + 0.95	**Cultivar must be tolerant to glyphosate (Roundup, etc.).** See comments for glyphosate alone. Dual Magnum can be applied overtop of cotton until 100 days before harvest and directed until 80 days of harvest; however, UGA research suggests making directed applications after the 8-leaf stage to reduce injury potential and improve weed control. Some leaf speckling/burn will likely occur. Avoid heavy dew on cotton plant, saturated soils, and extreme, hot conditions. Do not mix with Staple and do not apply within 5 days of Staple application.
	glyphosate + *S-metolachlor* Sequence 5.25L		24 H/ 100 D	2.5 pt	0.7 + 0.94	**Cultivar must be tolerant to glyphosate (Roundup, etc.).** Label allows application from cotyledon stage cotton to the 10 leaf stage (not to exceed 12" tall). Do not harvest within 100 days of application. See comments above for glyphosate + Dual Magnum.
Envoke will improve control of Ipomoea morningglory and nutsedge. It will also provide some residual control of sensitive weeds if it reaches the soil and is activated. **Will not control ALS + glyphosate resistant Palmer.**	*glyphosate* + *trifloxysulfuron* Envoke 75 WDG	9 + 2	24 H/ 60 D	see glyphosate + 0.1 oz	0.75-1.12 + 0.0047	**Cultivar must be tolerant to glyphosate (Roundup, etc.).** See comments for glyphosate and Envoke applied alone. Tank mix can be applied from 6 (prefer 7) leaf stage until 60 days of harvest; however, ***directed application strongly encouraged for improved weed control and much much less injury.*** **Make only 1 TIMELY application of Staple and/or Envoke per season.**

WEED	HERBICIDE	MOA	REI/PHI (Hours or Days)	BROADCAST RATE/ACRE		REMARKS AND PRECAUTIONS
				AMOUNT OF FORMULATION	LBS ACTIVE (AI or AE)	
POSTEMERGENCE OVER-THE-TOP BROADLEAF AND GRASS CONTROL FOR CULTIVARS TOLERANT TO GLYPHOSATE (ROUNDUP, ETC.) **Application of postemergence herbicide treatments to moisture stressed weeds usually results in poor control. (continued)**						
Volunteer Roundup Ready corn **in cotton tolerant to Roundup**	*glyphosate* + *clethodim* Select 2 EC Select Max 0.97EC	9 + 1	24 H/ 60 D	see glyphosate + 4-8 fl oz 6-12 fl oz	0.75-1.12 + 0.06-0.09	**Cultivar must be tolerant to glyphosate (Roundup, etc.).** For corn up to 12" tall, apply 4-6 oz of Select or 6 oz of Select Max; for corn up to 24" tall, apply 6-8 oz of Select or 9 oz of Select Max; for corn up to 36" tall, apply 12 oz of Select Max. Add 2.5 lb/A ammonium sulfate or equivalent and make sure glyphosate brand used contains adjuvant. Numerous generic formulations of clethodim are available.
	glyphosate + *fluazifop -p-butyl* Fusilade DX 2 EC	9 + 1	12 H/ 90 D	see glyphosate + 4-6 fl oz	0.75-1.12 + 0.06-0.09	**Cultivar must be tolerant to glyphosate (Roundup).** See comments for glyphosate alone. Apply Assure at 4 oz to corn up to 12", 5 oz for corn up to 18", and 8 oz to corn up to 30". Add 0.125% nonionic surfactant by volume.
	glyphosate + *quizalofop-p-ethyl* Assure II 0.88 EC	9 + 1	12 H/ 80 D	see glyphosate + 5-8 fl oz	0.75-1.12 + 0.03-0.05	**Cultivar must be tolerant to glyphosate (Roundup).** See comments for glyphosate alone. Apply Assure at 4 oz to corn up to 12", 5 oz for corn up to 18", and 8 oz to corn up to 30". Add 0.125% nonionic surfactant by volume.
Volunteer Roundup Ready soybean	*glyphosate* + *trifloxysulfuron* Envoke 75 WDG	9 + 2	12 H/ 60 D	see glyphosate + 0.1 oz	0.75-1.12 + 0.0047	**Cultivar must be tolerant to glyphosate (Roundup).**See comments above on glyphosate plus Envoke, especially regarding crop injury. 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 control soybean. **Make only 1 timely Envoke and/or Staple application per season.**
POSTEMERGENCE OVER-THE-TOP BROADLEAF AND GRASS CONTROL FOR CULTIVARS TOLERANT TO GLYPHOSATE AND GLUFOSINATE **Application of postemergence herbicide treatments to moisture stressed weeds usually results in poor control.**						
Mixing glyphosate with Liberty will not influence weed control by Liberty alone; however, grass control will often be more than Liberty alone but often less than that by glyphosate alone.	*glufosinate* Liberty 2.34 S + *glyphosate*	10 + 9	12 H/ 70 D	32 fl oz + varies	0.59 + 0.75	**Cultivar must be tolerant to glyphosate (Roundup) and glufosinate (Liberty, etc.).** See comments for Liberty and for glyphosate alone. Injury on Glytol LibertyLink Cotton is often < than on Enlist Cotton which is often < than on XtendFlex Cotton. Injury is often 5 to 10% greater than with glufosinate applied alone. Some leaf speckling/burn will likely occur. Injury may be enhanced if applied to cotton with dew, under extremely high temperatures, during times of saturated soils, or when mixed with insecticides or adjuvants. Research has shown in some environments, especially saturated soils, that more injury from Liberty is observed with XtendFlex cotton compared to LibertyLink cotton.

WEED	HERBICIDE	MOA	REI/PHI (Hours or Days)	BROADCAST RATE/ACRE		REMARKS AND PRECAUTIONS
				AMOUNT OF FORMULATION	LBS 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	1	24 H/ 60 D	 6-8 fl oz 9-16 fl oz 9-16 fl oz	 0.09-0.13 0.07-0.12 0.07-0.12	Apply to actively growing grasses not under stress. Mixtures with herbicides other than glyphosate will likely reduce grass control. Do not cultivate within 5 days of application. A 2nd application may be made. ***For Select:*** Add crop oil concentrate at 1 qt/A. ***For Select Max:*** Add nonionic surfactant at 1 qt/100 gal solution, crop oil concentrate at 1 gal/100 gal solution, or methylated seed oil at 1 gal/100 gal solution. ***For Fusilade:*** Apply with crop oil concentrate (preferred) at 1 gal/100 gal solution or nonionic surfactant at 1 qt /100 gal solution. ***For Assure:*** Apply with crop oil concentrate (preferred) at 1 gal/100 gal solution or nonionic surfactant at 1 qt/100 gal solution. ***For Poast:*** Add crop oil concentrate at 1 qt/A. Numerous generic formulations for each active ingredient are available.
	fluazifop p-butyl Fusilade DX 2 EC	1	12 H/ 90 D	8-12 fl oz	0.125 to 0.188	
	quizalofop p-ethyl Assure II 0.88 EC	1	12 H/ 80 D	7-8 fl oz	0.05-0.06	
	sethoxydim Poast 1.53 EC Poast Plus 1 EC	1	12 H/ 40 D	 16 fl oz 24 fl oz	0.19	
Perennial grasses	*clethodim* Select, others 2 EC Select Max 0.97 EC Tapout 0.97 EC	1	24 H/ 60 D	 8-16 fl oz 12-32 fl oz 12-32 fl oz	 0.13-0.25 0.09-0.24 0.09-0.24	Apply to actively growing johnsongrass 12-24" tall or to bermudagrass with runners up to 6". A second application at the provided rates may be made to bermudagrass when regrowth is up to 6" or when johnsongrass has regrowth of 6-18". Add adjuvant as provided above in annual grass section. Do not mix with other herbicides. Do not cultivate within 7 days before or after application.
	fluazifop p-butyl Fusilade DX 2 EC	1	12 H/ 90 D	10-12 fl oz	0.156-0.188	Apply when johnsongrass is 8-18" or when bermudagrass runners are 4-8". If needed, make a second application of 8 fl oz/A when johnsongrass regrowth or new plants are 6-12" inches or when bermudagrass stolon (runner) regrowth or new plants are 3-6". Apply with crop oil concentrate (preferred) at 1 gal/100 gal solution or nonionic surfactant at 1 qt/100 gal solution. Do not mix with other herbicides. Do not cultivate within 5 days of application.

WEED	HERBICIDE	MOA	REI/PHI (Hours or Days)	BROADCAST RATE/ACRE		REMARKS AND PRECAUTIONS
				AMOUNT OF FORMULATION	LBS 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. (continued)**						
Perennial grasses (continued)	*quizalofop p-ethyl* Assure II 0.88 EC	1	12 H/ 80 D	 10 fl oz	0.07	Apply when johnsongrass is 10-24" or bermudagrass runners are 3-6". A second application for treating regrowth or new plants can be made with 7 fl oz/A when johnsongrass reaches 6-10" or bermudagrass reaches 3-6". Apply with crop oil concentrate (preferred) at 1 gal/100 gal solution or nonionic surfactant at 1 qt/100 gal solution. Do not mix with other herbicides. Do not cultivate within 5 days of application.
	sethoxydim Poast 1.53 EC Poast Plus 1 EC	1	12 H/ 40 D	 24 fl oz 36 fl oz	0.28	Apply to johnsongrass up to 25" and before bermudagrass runners exceed 6". If regrowth occurs or new plants emerge, make a second application of 16 fl oz/A of Poast when johnsongrass reaches 6-10" and bermudagrass reaches 3-6". Add 1 qt of crop oil concentrate/A. Do not tank mix with other herbicides. Do not cultivate within 5 days of application.
POSTEMERGENCE DIRECTED – ANY COTTON CULTIVAR **Application of postemergence herbicide treatments to moisture stressed weeds usually results in poor control.**						
Effective control of many broadleaf weeds and nutsedge. Grasses should be less than 1". Residual control of many weeds if activated. **Diuron plus MSMA is the best directed option to control emerged glyphosate-resistant Palmer amaranth.** Diuron is more effective in controlling emerged pigweed than Cotoran or Valor. Valor provides more effective residual control of pigweed.	*diuron* Direx, Diuron, other 4F + *MSMA* (several brands) 6 lb/gal 6.6 lb/gal	7 + 17	12 H/ 1st Bloom	 1.6-2.4 pt + 2 pt 2 pt	 0.8-1.2 + 1.5 1.65	Apply as directed spray to cotton at least 12" tall. Addition of an adjuvant is 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 have 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 prohibits applying MSMA after 1st bloom. ***To Improve Emerged Morningglory Control Consider Adding:*** 1)Envoke at 0.1oz/A which poses no additional injury concern with 12" or taller cotton; or 2) Aim or ET at 0.5-1 fl oz/A where cotton should be at least 20" tall having 3" of bark with spray only contacting barky portion of the stem. Aim will also improve spiderwort control. ***To Improve Spiderwort and Grass Residual Control Consider Adding:*** 1) Dual Magnum 1 pt/A; or 2) Warrant 2-3 pt/A; or 3) Zidua 0.75 to 1.5 oz/A as long as cotton has at least 7-leaf. Numerous formulations of diuron and MSMA are available.
	diuron + linuron Layby Pro 4F + *MSMA* (several brands) 6 lb/gal 6.6 lb/gal	7 + 7 + 17	24 H/ 1st Bloom	 2 pt + 2 pt 2 pt	0.5 + 0.5 + 1.5 1.65	Apply as a directed spray to cotton at least 16" tall. Add crop oil concentrate at 1 gal/100 gal spray mix. Label prohibits use on sand or loamy sand soils, or on any soil with less than 1% organic matter. Label prohibits applying MSMA after first bloom.

WEED	HERBICIDE	MOA	REI/PHI (Hours or Days)	BROADCAST RATE/ACRE		REMARKS AND PRECAUTIONS
				AMOUNT OF FORMULATION	LBS 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 and nutsedge; grasses should be 1" or less. Palmer amaranth should be 2" or less. Residual control of many weeds if activated. Diuron is more effective in controlling emerged pigweed than Cotoran or flumioxazin; flumioxazin provides the most effective residual control of Palmer amaranth.	*flumioxazin* Valor SX, others 51 WDG + *MSMA* (several brands) 6 lb/gal 6.6 lb/gal	14 + 17	12 H/ 1st Bloom	2 oz + 2.67 pt 2.5 pt	0.064 + 2	Apply as a directed spray to cotton at least 18" tall. Direct spray to the lower 2" of the cotton stem and do not contact the green portion of the cotton stem. May apply to 6" cotton under a hood. Add nonionic surfactant at 1 qt/100 gal spray mix. DO NOT use crop oil concentrate, methylated seed oil, organo-silicone adjuvant, or any adjuvant containing any of these. Label prohibits applying MSMA after 1st bloom. IN HOODED APPLICATIONS when no contact of the cotton crop occurs; the addition of Dual type product or Warrant is recommend for managing tropical spiderwort and glyphosate- resistant Palmer amaranth. Outflank, Panther, and Rowel have been tested and perform similarly to Valor. **For PPO-resistance management, make only 3 applications of Valor or Reflex (including generics) in 3 years.**
Currently, the single best layby mixture for both control of emerged glyphosate-resistant Palmer amaranth and extended residual control.	*flumioxazin* Valor SX, others 51 WDG + *diuron* Direx, others 4F + *MSMA* (several brands) 6 lb/gal 6.6 lb/gal	14 + 7 + 17	12 H/ 1st Bloom	2 oz + 1 pt + 2 pt 2 pt	0.064 + 0.5 + 1.5 1.65	See restrictions for each product applied alone. Cotton should be at least 20" tall. Apply as a directed spray to the lower 2" of the barky portion of the cotton stem. Experiment with this mixture on limited acreage as crop injury is of some concern. Add nonionic surfactant at 1 qt/100 gal spray mix. DO NOT use crop oil concentrate, methylated seed oil, organo-silicone adjuvant, or any adjuvant containing any of these. Label prohibits applying MSMA after 1st bloom.
Effective control of many broadleaf weeds and nutsedge; grasses should be less than 1" and Palmer 2" or less. Will not improve control of emerged weeds but better residual control when compared to flumioxazin alone.	*flumioxazin+pyroxasulfone* Fierce 76 WDG + *MSMA* 6 lb/gal 6.6 lb/gal	14 + 15 + 17	12 H/ 1st Bloom	3 oz + 2.67 pt 2.5 pt	0.063+0.08 + 2	Apply as a directed spray to cotton at least 18" tall. Direct spray to the lower 2" of a barky cotton stem; do not contact the green portion of the cotton stem. May apply to 6" cotton under a hood. Add nonionic surfactant at 1 qt/100 gal spray mix. DO NOT use crop oil concentrate, methylated seed oil, organo-silicone adjuvant, or any adjuvant containing any of these. Label prohibits applying MSMA 1st bloom.
Effective control of many broad-leaf weeds, nutsedge, and small annual grasses. Residual control of many weeds. Much less effective than diuron + MSMA in controlling emerged pigweed and less residual than diuron or Valor.	*fluometuron* Cotoran 4F + *MSMA* (several brands) 6 lb/gal 6.6 lb/gal	7 + 17	12 H/ 1st Bloom	2-3.2 pt + 2.67 pt 2.5 pt	1-1.6 + 2	Apply as a directed spray to cotton at least 3" tall; cotton has very good tolerance. Label prohibits applying MSMA after 1st bloom. The addition of a Dual type product or Warrant is recommended for managing tropical spiderwort and Palmer amaranth.

WEED	HERBICIDE	MOA	REI/PHI (Hours or Days)	BROADCAST RATE/ACRE		REMARKS AND PRECAUTIONS
				AMOUNT OF FORMULATION	LBS ACTIVE (AI or AE)	
POSTEMERGENCE DIRECTED – ANY COTTON CULTIVAR **Application of postemergence herbicide treatments to moisture stressed weeds usually results in poor control. (continued)**						
Effective control of many broadleaf weeds, nutsedge, and small annual grasses. Limited residual control especially on pigweeds. Much less effective than diuron + MSMA in controlling emerged pigweed and less residual than diuron or Valor.	*prometryn* Caparol 4F + *MSMA* (several brands) 6 lb/gal 6.6 lb/gal	5 + 17	12 H/ 1st Bloom	 1.3-2.4 pt + 2.67 pt 2.5 pt	0.65-1.2 + 2	Apply as a directed spray. Use 1.3 pt/A Caparol in 8-12" cotton and up to 2.4 pt/A in cotton at least 12". Add nonionic surfactant at 2 qt/100 gal spray solution. Label prohibits applying after 1st bloom. The addition of Envoke, Aim, or ET will improve morningglory control. Envoke at 0.1 oz/A poses no additional injury concern and the mixture can be applied to 12" or larger cotton. For Aim or ET at 0.5-1 fl oz/A, cotton should be at least 20" tall having 3" of bark with spray not contacting green portion of stem. Aim will also improve spiderwort control. The addition of a Dual type product or Warrant is recommended for managing tropical spiderwort.
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 lb/gal 6.6 lb/gal	5 + 2 + 17	12 H/ 1st Bloom	 1-1.25 lb + 2.67 pt 2.5 pt	0.8-1 + 0.007-0.009 + 2	Apply as directed spray in cotton at least 8" tall. Add nonionic surfactant at 1 qt/100 gal spray mix. See rotation restrictions on label. Label prohibits applying MSMA after first bloom. Do not exceed 0.0188 lb ai/A per year of trifloxysulfuron from the combined use of Envoke and Suprend. Suprend is formulated as 79.3% prometryn plus 0.7% trifloxysulfuron.
POSTEMERGENCE DIRECTED—COTTON CULTIVARS TOLERANT TO GLYPHOSATE (ROUNUDP, ETC.) **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* 4S (3 lb ae) 5.4S (4 lb ae) 5S (4.17 lb ae) 5.5S (4.5 lb ae) 6S (5 lb ae)	9	4 H/ 7 D	 32-48 fl oz 24-36 fl oz 23-34 fl oz 22-32 fl oz 19-29 fl oz	0.75-1.12	**Cultivar must be tolerant to glyphosate (Roundup, etc.).** Glyphosate should never be applied alone but label allows directed application up to 7 days prior to harvest. Improved weed coverage with a directed application generally occurs after 8-leaf cotton. **A glyphosate-based program should include: 1) no weeds emerged at planting; 2) two residual herbicides at planting; and 3) residual herbicides with Roundup POST and a conventional directed layby. Obtain programs from the local Extension office or at gaweed.com.**
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. Residual Palmer control by diuron alone will last 7-10 days in most conditions.	*glyphosate* + *diuron* Direx, Diuron 4F	9 + 14	12 H/ 7 D	see glyphosate + 1-1.5 pt	0.75-1.12 (lb ae) + 0.5-0.75	**Cultivar must be tolerant to glyphosate (Roundup, etc.).** Use 1 pt/A of diuron on cotton 8-12" and up to 1.5 pt/A of diuron on cotton greater than 12". ***To Improve spiderwort, pigweed, and grass residual control consider adding:*** 1) Dual Magnum 1 pt/A; 2) Warrant 2-3 pt/A; 3) Zidua 0.75-1.5 oz/A as long as cotton has at least 7-leaf; or 4) Outlook 12-16 oz/A. ***To Improve Morningglory Control Consider Adding:*** 1) Envoke 0.1 oz/A, no additional restrictions; 2) Valor 1-1.5 oz/A, cotton should be at least 18" tall with spray contacting only bottom 2" of barky stem; or 3) Aim or ET 0.5-1 oz/A, cotton should be at least 20" with spray contacting bottom 2" of barky stem only.

WEED	HERBICIDE	MOA	REI/PHI (Hours or Days)	BROADCAST RATE/ACRE		REMARKS AND PRECAUTIONS
				AMOUNT OF FORMULATION	LBS ACTIVE (AI or AE)	
POSTEMERGENCE DIRECTED – COTTON CULTIVAR MUST BE TOLERANT TO GLYPHOSATE (ROUNDUP, ETC.) Application of postemergence herbicide treatments to moisture stressed weeds usually results in poor control. (continued)						
Mixture improves morningglory and tropical spiderwort control and provides residual control of broadleaf weeds including pigweeds, purslane, and Florida pusley. Often poor control of glyphosate-resistant Palmer amaranth over 1".	*glyphosate* + *flumioxazin* Valor SX 51WDG	9 + 14	12 H/ 60 D	see glyphosate + 1-2 oz	0.75-1.12 (lb ae) + 0.031-0.063	**Cultivar must be tolerant to glyphosate (Roundup).** Cotton should be at least 18". Direct spray to the lower 2" of barky cotton stem. Do not allow spray to contact green portion of stem. ***The addition of diuron will improve control of emerged pigweed.*** Add nonionic surfactant at 1 qt/100 gal spray mix but only if glyphosate brand requires adjuvant. DO NOT use crop oil concentrate, methylated seed oil, organo-silicone adjuvants, or any adjuvant product containing these. Outflank, Panther, and Rowel have been tested and perform similarly to Valor. **For PPO-resistance management, make only 3 applications of Valor or Reflex (including generics) on a field in 3 years.**
Provides similar postemergence control as glyphosate + Valor but provides greater residual control for many weeds including spiderwort and Palmer amaranth.	*glyphosate* + *flumioxazin + pyroxasulfone* Fierce 76 WDG	9 + 14 + 15	12 H/ 60 D	see glyphosate + 3 oz/A	0.75-1.12 (lb ae) + 0.063-0.08	**Cultivar must be tolerant to glyphosate (Roundup).** Apply as a directed spray to cotton at least 18" tall. Direct spray to the lower 2" of a barky cotton stem; do not contact the green portion of the cotton stem. May apply to 6" cotton under a hood. Add nonionic surfactant according to the Fierce label. DO NOT use crop oil concentrate, methylated seed oil, organosilicone adjuvant, or any adjuvant containing any of these.
Mixture improves morningglory control and provides residual control of sensitive species. The tank mix may give less grass control than glyphosate alone.	*glyphosate* + *prometryn* Caparol 4F	9 + 5	12 H/ --	see glyphosate + 1-2 pt	0.75-1.12 (lb ae) + 0.5-1	**Cultivar must be tolerant to glyphosate (Roundup).** Cotton should be at least 8" for Caparol rate between 1-1.3 pt and at least 12" for Caparol rate above 1.3 pt. Add surfactant but only if glyphosate brand requires it. ***To Improve Spiderwort, Pigweed, and Grass Residual Control Consider Adding:*** 1) Dual Magnum 1 pt/A; 2) Warrant 2-3 pt/A; 3) Zidua 0.75-1.5 oz/A as long as cotton has at least 7-leaf; or 4) Outlook 12-16 oz/A. ***To Improve Morningglory Control Consider Adding:*** 1) Envoke 0.1 oz/A, no additional restrictions; 2) Valor 1-1.5 oz/A, cotton should be at least 18" tall with spray contacting only bottom 2" of barky stem; or 3) Aim or ET 0.5-1 oz/A, cotton should be at least 20" with spray contacting bottom 2" of barky stem only. Occasionally, directed applications to succulent cotton stems cause chlorosis from Caparol throughout the plant.

WEED	HERBICIDE	MOA	REI/PHI (Hours or Days)	BROADCAST RATE/ACRE		REMARKS AND PRECAUTIONS
				AMOUNT OF FORMULATION	LBS ACTIVE (AI or AE)	
POSTEMERGENCE DIRECTED – COTTON CULTIVAR MUST BE TOLERANT TO GLYPHOSATE (ROUNDUP, ETC) (continued) Application of postemergence herbicide treatments to moisture stressed weeds usually results in poor control.						
Mixing Envoke with glyphosate improves *Ipomoea* morningglory and nutsedge control and provides some residual control of sensitive species.	*glyphosate* + *trifloxysulfuron* Envoke 75 WDG	9 + 2	12 H/ 60 D	see glyphosate + 0.1-0.2 oz	0.75-1.12 (lb ae) + 0.005-0.009	**Cultivar must be tolerant to glyphosate (Roundup).** Direct to cotton from 6" tall through layby; minimize contact on small cotton. Add nonionic surfactant according to Envoke label. Excellent tolerance when directed. The addition of diuron would greatly improve control of emerged Palmer amaranth. **Make no more than 1 application of Envoke or Staple per season.**
Mixing Suprend with glyphosate improves control of morningglory, pigweeds, and nutsedge. Also provides residual weed control of sensitive species.	*glyphosate* + *prometryn* + *trifloxysulfuron* Suprend 80 WDG	9 + 5 + 2	24 H/ 60 D	see glyphosate + 1-1.25 lb	0.75-1.12 (lb ae) + 0.8-1 + 0.007-0.0088	**Cultivar must be tolerant to glyphosate (Roundup).** Direct to cotton at least 8"tall. Add surfactant according to label of glyphosate brand used. See precautions and rotational restrictions on Suprend label.
POSTEMERGENCE-HOODED SPRAYER						
Glyphosate as a hooded application is especially effective for prostrate, running species such as citron, burgherkin, and annual grasses. SUGGEST NOT USING LIQUID NITROGEN AS ENTIRE CARRIER.	*glyphosate* 4S (3 lb ae) 5.4S (4 lb ae) 5S (4.17 lb ae) 5.5S (4.5 lb ae) 6S (5 lb ae)	9	4 H/ 7 D	 32-48 fl oz 24-36 fl oz 23-34 fl oz 22-32 fl oz 19-29 fl oz	0.75-1.12 (lb ae)	In varieties not resistant to glyphosate, hoods should be kept as close to the ground as possible preventing spray from contacting stems or foliage. Apply in 5-10 GPA at a maximum of 25 PSI. Do not exceed 5 MPH. Suggest that cotton be at least 8" tall. Other herbicides such as Aim, Caparol, diuron, Dual Magnum, Envoke, ET, Staple, Valor, and Warrant may be mixed with certain glyphosate formulations to improve burndown in larger cotton. All of these products except Aim or ET will also offer residual weed control for some troublesome weeds. Grass control may be reduced with tank mixes of glyphosate plus Caparol or diuron.
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 2S	22	24 H/ 3 D	 19-38 fl oz	0.3-0.6	DO NOT CONTACT COTTON STEMS OR FOLIAGE. Apply in a minimum of 10 GPA at a maximum of 25 PSI. Do not exceed 5 MPH. Hoods should be kept on the ground. Cotton should be at least 8". Add nonionic surfactant at 2 pt/100 gal of spray mix or crop oil concentrate at 1 gal/100 gal spray mix. Caparol, Cotoran, or diuron (Direx, diuron) mixed with paraquat will likely improve control of emerged weeds while also providing residual control. ***If paraquat contacts the cotton stem, severe damage is to be expected!***

WEED	HERBICIDE	MOA	REI/PHI (Hours or Days)	BROADCAST RATE/ACRE		REMARKS AND PRECAUTIONS
				AMOUNT OF FORMULATION	LBS ACTIVE (AI or AE)	
POSTEMERGENCE-HOODED SPRAYER (continued)						
Timing for pigweed and grasses are critical. Control of pusley, spiderwort, and goosegrass is not consistent. Generally, treat broadleaf weeds prior to 3" and grasses prior to 2". Excellent control of morning-glory including moonflower morningglory. ***Make no more than 2 applications of Liberty per year.***	*glufosinate-ammonium* Liberty 2.34 S	10	12 H/ 70 D	29 fl oz	0.53	On non-glufosinate tolerant cotton, keep hoods close to ground to avoid contact with cotton stem. Suggest cotton be at least 8". The addition of diuron or other residual herbicide strongly encouraged. Adjuvant not needed. ***To maximize control:*** >15 GPA water volume, medium spray droplet, warm temperatures, high humidity, bright sunlight, good soil moisture, and do not spray within 1.5 hours of sunrise or 1 hour of sunset. **Palmer amaranth should be less than 3 inches when treated with glufosinate at this rate; diuron + MSMA is more effective on emerged pigweed.** Numerous other brands of glufosinate are available.
HARVEST AID						
Mature morningglory	*carfentrazone-ethyl* Aim 2 EC	14	12 H/ 7 D	up-1.5 fl oz	up-0.024	Apply as a harvest aid when 60-70% 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 for potential negative influence on defoliation activity.
	pyraflufen ethyl ET 0.208 EC	14	12 H/ 7 D	up-2.75 oz	up-0.0044	Apply as a harvest aid when 60-70% 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 for potential negative influence on defoliation activity.

WEED	HERBICIDE	MOA	REI/PHI (Hours or Days)	BROADCAST RATE/ACRE		REMARKS AND PRECAUTIONS
				AMOUNT OF FORMULATION	LBS ACTIVE (AI or AE)	
HARVEST AID (continued)						
Desiccation of most weeds. Regrowth of many weeds occurs soon after application.	*paraquat* Gramoxone Inteon 2S	22	24 H/ 3 D	16-32 fl oz	0.25-0.5	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/100 gal spray mix. Wait 3-5 days and pick the cotton as soon as possible. Expect additional trash. An additional option is to add 2-6 oz of Gramoxone Inteon with standard defoliation mixtures. **Be aware of potential pine tree and other sensitive crop/plant injury with drift.** Generic brands of paraquat containing 3 lb ai/gal may be labeled. These products would be applied at 11-21 fl oz for 0.25-0.5 lb ae, respectively. See cotton defoliation section.
Annual grasses and broadleaf weeds	*glyphosate* 4 SL (3 lb ae) 5.4 SL (4 lb ae) 5 SL (4.17 lb ae) 5.5 SL (4.5 lb ae) 6 SL (5 lb ae)	9	4 H/ 7 D	 32-64 fl oz 24-48 fl oz 23-46 fl oz 22-44 fl oz 19-38 fl oz	0.75-1.5 (lb ae)	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 until 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

A. Stanley Culpepper, Extension Agronomist-Weed Science

WEED SPECIES	BURNDOWN TREATMENT[1]									
	2,4-D[3]	glyphosate	glyphosate[2] + 2,4-D[3]	glyphosate[2] + dicamba[4]	glyphosate[2] + Aim or ET	glyphosate[2] + Direx[7]	glyphosate[2] + Harmony Extra[5]	glyphosate[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	E	E	G	E	E	F-G	G
goosegrass	N	E	G-E	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	E	E	G	E	E	G	G-E
volunteer corn (not RR vol.corn)	N	E	E	E	E	E	E	E	F	F-G
purple nutsedge	N	F-G	F-G	F-G	F-G	F-G	F-G	G	P-F	F
yellow nutsedge	N	P-F	P-F	P-F	P-F	F	P-F	F	P-F	F
BROADLEAVES										
bristly starbur	G	E	E	E	E	E	E	E	E	E
buttercup	G	E	E	E	E	E	E	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	G-E		E	F-G	G-E
cowpea	G	E			E	E		E	E	E
cudweed	P	E	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		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	F-G	G	F-G	G	E	G-E	G[8]	E[8]

WEED SPECIES	BURNDOWN TREATMENT[1]									
	2,4-D[3]	glyphosate	glyphosate[2] + 2,4-D[3]	glyphosate[2] + dicamba[4]	glyphosate[2] + Aim or ET	glyphosate[2] + Direx[7]	glyphosate[2] + Harmony Extra[5]	glyphosate[2] + Valor SX[6]	paraquat	paraquat + Direx[7]
BROADLEAVES (continued)										
horsenettle	F	F	F-G		P-F	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	F-G	E	E	G-E	G-E			F-G	G
morningglory, *Ipomoea*	G-E	F	E	E	E	G	F	E	F-G	G-E
morningglory, smallflower	F-G	G	E	E	G-E	G-E	G	E	P	F-G
Palmer amaranth	F[9]	E	E	E	E	E	E	E	F-G	G-E
Palmer amaranth (glyphosate-resistant)	[9]	N	[9] F	F	P-F	G	P	P-F	F-G	G-E
Pennsylvania smartweed	F	G	G	E	G-E	G	E		P-F	F-G
prickly sida	F-G	F-G	G	E	F-G	F-G	F-G		P-F	F-G
purslane	G-E	F	G-E	E	F-G	G	F	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	P	G	G	G-E
velvetleaf	F-G	G			G-E	G			P	P

Key:
E = 90% or better control
G = 80%-90% control
F = 60%-80% control
P = 30%-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.

[1]Application rates per acre: Clarity (dicamba): 0.5 pt; 2,4-D: 1 pt; Aim: 1 oz; ET: 1-2 oz; diuron: 0.5-1.0 lb ai; glyphosate acid: 0.75 lb ae; paraquat: 0.75-1.0 lb ai; Harmony Extra TotalSol: 0.75 oz; Valor: 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 dicamba and a minimum of 1" of rainfall, a minimum 21-day waiting period before planting is required.
[5]Harmony Extra should be applied at least 14 days prior to planting.
[6]See plant-back restrictions noted in the previous section or on the label for Valor.
[7]See previous cotton section on state label for reduced plant back interval for Direx.
[8]This level of control requires plants to be in full bloom with seed forming when treated.
[9]This level of control requires 2 pt of 2,4-D (4 lb ai product).
[10]Glyphosate will not control glyphosate-resistant horseweed, see previous section on controlling this weed.
[11]Small grain must have visible seedheads for this level of control.

WEED RESPONSE TO BURNDOWN HERBICIDES USED IN COTTON

(continued)

WEED SPECIES	BURNDOWN TREATMENT[1]									
	2,4-D[3]	glyphosate	glyphosate[2] + 2,4-D[3]	glyphosate[2] + dicamba[4]	glyphosate[2] + Aim or ET	glyphosate[2] + Direx[7]	glyphosate[2] + Harmony Extra[5]	glyphosate[2] + Valor SX[6]	paraquat	paraquat + Direx[7]
BROADLEAVES (continued)										
vines (maypop, trumpet creeper)	F	P-F			P-F	F			P	P
Virginia pepperwee	G-E	G	E	G-E	G	G	G	G-E	G	G
volunteer peanuts	P	P-F	P-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-E	F-G	E	G-E	G	G	E	G	F-G[8]	G-E[8]
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	E	F	E	E	F	F-G	G	F-G	P-F[8]	F-G[8]

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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.

[1]Application rates per acre: Clarity (dicamba): 0.5 pt; 2,4-D: 1 pt; Aim: 1 oz; ET: 1-2 oz; diuron: 0.5-1.0 lb ai; glyphosate acid: 0.75 lb ae; paraquat: 0.75-1.0 lb ai; Harmony Extra TotalSol: 0.75 oz; Valor: 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 dicamba and a minimum of 1" of rainfall, a minimum 21-day waiting period before planting is required.
[5]Harmony Extra should be applied at least 14 days prior to planting.
[6]See plant-back restrictions noted in the previous section or on the label for Valor.
[7]See previous cotton section on state label for reduced plant back interval for Direx.
[8]This level of control requires plants to be in full bloom with seed forming when treated.
[9]This level of control requires 2 pt of 2,4-D (4 lb ai product).
[10]Glyphosate will not control glyphosate-resistant horseweed, see previous section on controlling this weed.
[11]Small grain must have visible seedheads for this level of control.

WEED RESPONSE TO HERBICIDES USED IN COTTON

A. Stanley Culpepper, Extension Agronomist-Weed Science

WEED SPECIES	PREPLANT INCORPORATED	PREEMERGENCE							
	Prowl Treflan others	Prowl[1], others	Brake F16	Command	Cotoran	Direx, others	Reflex, Dawn	Staple, Pyrimax	Warrant
PERENNIALS									
bermudagrass	N	N		P-F	N	N	N	N	N
johnsongrass (rhizome)	P	P		N	N	N		N	P
yellow nutsedge	N	N	G	N	N	N	G-E	F	P
purple nutsedge	N	N	F	N	N	N	P-F	F	P
ANNUAL GRASSES									
broadleaf signalgrass	G	F		E	P	P	F-G	P	G
crabgrass	E	G		E	F-G	F-G	F-G	P	E
crowfootgrass	E	G		G	F-G	F-G			E
fall panicum	G	F-G		G-E	F	P		P-F	G
foxtails	E	G		E	F-G			P	E
goosegrass	E	G		E	F	F		P-F	E
johnsongrass (seedling)	E	G		G	P	P		F-G	F
sandbur	E	G		F-G	G	G			F-G
Texas panicum	G	F		F	P	P	F	N	P-F
ANNUAL BROADLEAVES									
bristly starbur	N	N		P	G-E	F-G	G-E	F-G	P
burgherkin	N	N		P	F-G	F		F-G	P
citronmelon	N	N		P	F-G	F		F-G	P
cocklebur	N	N		F	F-G	F	G	N-P	P
coffee senna	N	N		P	F-G	F	N	G	P
cowpea	N	N		N-P	P	P		F-G	P
crotalaria	N	N			G	G			P
eclipta	P	P			G		G-E		
Florida beggarweed	P	P		F-G	G-E	G	P	G	P

Key:
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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.

[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.

WEED SPECIES	PREPLANT INCORPORATED		PREEMERGENCE						
	Prowl Treflan others	Prowl[1], others	Brake F16	Command	Cotoran	Direx, others	Reflex, Dawn	Staple, Pyrimax	Warrant
ANNUAL BROADLEAVES (continued)									
Florida pusley	E	F-G		F-G	P-F	P	F	G	
hemp sesbania	N	F		P	P	P	P	P	
jimsonweed	N	N		G	G	G		F-G	
lambsquarters	G-E	G		G	G-E	G-E	E	G	F
morningglories *Ipomoea* smallflower	P	P	F G-E	P-F[2] P	G G-E	F G	P-F G-E	F[3] E	P P
Palmer amaranth	F-G	P-F	E	N-P	F	G	E	G-E[3]	G
pigweeds: redroot or smooth	G-E	F-G	E	P	G-E	G-E	E	E	G-E
prickly sida	N	N		E	G	F		G	F
purslane	E	G		G-E	E	E	G	G	G
ragweed	N	N		G	E	G	G	N-P	P
redweed	N	N		G-E	E	G-E		G-E	
smartweed: ladysthumb Pennsylvania	N	N		N E	G G	G G		G G	
sicklepod	N	N	P	P	G	F	P	P-F	P
spurge	N	N		N	P-F	F		G	P-F
tropic croton	N	N		E	F-G	F-G	F-G	F-G	P
tropical spiderwort	N	N		F	F	P-F	N	P	E
volunteer peanuts	N	N	P	N	P-F	P	P	P	N
wild poinsettia	N	N		F	N	N	G-E	G	P

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

[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.

WEED SPECIES	Residual Control by POST Applied Herbicides (Assuming soil contact and activation)			
	Dual Magnum	Staple	Envoke	Warrant
PERENNIALS				
bermudagrass	N	N	N	N
johnsongrass (rhizome)	P	N	N	P
yellow nutsedge	F	P-F		P
purple nutsedge	P	F		P
ANNUAL GRASSES				
broadleaf signalgrass	G	P	P	G
crabgrass	E	P	P	E
crowfootgrass	E		P	E
fall panicum	G	P-F	P	G
foxtails	E	P	P	E
goosegrass	E	P-F	P	E
johnsongrass (seedling)	F	F	P	F
sandbur	F-G		P	F-G
Texas panicum	P-F	N	P	P-F
ANNUAL BROADLEAVES				
bristly starbur	P	G	G-E	P
burgherkin	P	F-G		P
citronmelon	P	F-G		P
cocklebur	P	N-P		P
coffee senna	P	G		P
cowpea	P	F-G		P
crotalaria	P			P
eclipta	P-F			
Florida beggarweed	P-F	G	F-G	P-F
Florida pusley	G	F	P-F	G
hemp sesbania	P	P		P
jimsonweed		F-G		
lambsquarters	F	G		F
morningglorie *Ipomoea* smallflower	P P	F[3] E	 P-F	P P
Palmer amaranth	G	G-E[3]	P-F	G
pigweeds: redroot or smooth	G-E	G-E	F	G-E

WEED SPECIES	Residual Control by POST Applied Herbicides (Assuming soil contact and activation)			
	Dual Magnum	Staple	Envoke	Warrant
ANNUAL BROADLEAVES				
prickly sida	F	G		F
purslane	G	G		G
ragweed	P	N-P		P
redweed		G-E		
smartweed: ladysthumb Pennsylvania		G G		
sicklepod	P	P	P-F	P
spurge	P-F	G		P-F
tropic croton	P	F		P
tropical spiderwort	E	P		E
volunteer peanuts	N	P	P	N
wild poinsettia	P	G		P

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

[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.

WEED SPECIES	POST OVER-THE-TOP					
	Assure, others	Fusilade, others	Poast	Select/Select Max, others	MSMA	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

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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, others	Fusilade, others	Poast	Select/Select Max, others	MSMA	Cotoran
ANNUAL BROADLEAVES (continued)						
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 Pennsylvani	N N	N N	N N	N N	N-P N-P	F-G 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

Key:
E = 90% or better control
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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, Pyrimax	Envoke	Envoke + Staple	glyphosate[2]	glyphosate[2] + Staple, Pyrimax	glyphosate[2] + Envoke	Liberty[3], others
PERENNIALS							
bermudagrass	N	N	N	F	F	F	N
johnsongrass (rhizome)	N-P	P	N-P	G-E	G-E	G-E	F[4]
purple nutsedge	P-F	F-G	F-G	F-G	F-G	G	P
yellow nutsedge	P-F	G	G	F	F-G	G-E	P
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	N-P	N-P	E	E	E	G
goosegrass	N	N-P	N-P	E	E	E	P
johnsongrass (seedling)	P	P	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		

Key:
E = 90% or better control
G = 80%-90% control
F = 60%-80% control
P = 30%-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.

[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]Glufosinate (Liberty, others) should be applied only to tolerant cotton.
[4]Good johnsongrass control can be obtained with two applications of Liberty.

WEED SPECIES	POST OVER-THE-TOP						
	Staple, Pyrimax	Envoke	Envoke + Staple	glyphosate[2]	glyphosate[2] + Staple, Pyrimax	glyphosate[2] + Envoke	Liberty[3], others
ANNUAL BROADLEAVES (continued)							
jimsonweed	E	N		E	E	E	E
lambsquarters	N	G		G	G	E	E
Ipomoea morningglories	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	F-G	G	F
purslane	F			F-G	G	G	F
ragweed, common	P	G		E	E	E	E
redweed	G			E	E		
sicklepod	P-F	E	E	E	E	E	E
smartweed: ladysthumb Pennsylvania	G G	G G		G G	E E	E 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

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[4]Good johnsongrass control can be obtained with two applications of Liberty.

WEED SPECIES	POSTEMERGENCE-DIRECTED							
	MSMA	Cotoran + MSMA	Caparol + MSMA	Direx, others + MSMA	Direx + Linex + MSMA	Cobra + MSMA	Valor, others + 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	P-F	F	F
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	E
crotalaria	G	G	G	G	G	G		E
eclipta		G	G	E	E	E	E	E
Florida beggarweed	E	E	E	E	E	E	E	E

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WEED SPECIES	POSTEMERGENCE-DIRECTED							
	MSMA	Cotoran + MSMA	Caparol + MSMA	Direx, others + MSMA	Direx + Linex + MSMA	Cobra + MSMA	Valor, others + MSMA	Suprend + MSMA
ANNUAL BROADLEAVES (continued)								
Florida pusley	P	F	F	F	F	F	F-G	F
hemp sesbania	N	P-F	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	P-F	F-G	G	G	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	
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	

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WEED SPECIES	POSTEMERGENCE-DIRECTED							HOOD
	glyphosate[1]	glyphosate[1] + Direx, diuron	glyphosate[1] + Aim	glyphosate[1] + Envoke	glyphosate[1] + Staple, Pyrimax	glyphosate[1] + Valor, others	Liberty[2], others	Gramoxone + Direx, diuron
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			

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WEED SPECIES	POSTEMERGENCE-DIRECTED							HOOD
	glyphosate[1]	glyphosate[1] + Direx, diuron	glyphosate[1] + Aim	glyphosate[1] + Envoke	glyphosate[1] + Staple, Pyrimax	glyphosate[1] + Valor, others	Liberty[2], others	Gramoxone + Direx, diuron
ANNUAL BROADLEAVES (continued)								
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	G-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
Palmer amaranth (glyphosate-resistant)	N	F-G	P-F	P	F	P-F	F-G	G-E
Palmer amaranth (glyphosate & ALS resis.)	N	F-G	P-F	N	N	P-F	F-G	G-E
pigweed: redroot or smooth	E	E	E	E	E	E	G	G-E
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

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When you have a question . . .

Call or visit your local office of The University of Georgia's Cooperative Extension Service.

You'll find a friendly, well-trained staff ready to help you with information, advice and free publications covering agriculture and natural resources, home economics, 4-H and youth development and resource development.

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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