2024

Georgia Cotton

PRODUCTION GUIDE

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UNIVERSITY OF GEORGIA
EXTENSION

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THE 2024 CROP YEAR IN REVIEW

It seems that every year this publication begins with "The (insert year here) growing season was far from normal." So, to keep on trend, the 2023 growing season was far from normal. Different challenges are faced by growers every year, and this one was no different. Typically, we have a prolonged dry spell that begins in April through May, and generally in June it starts raining again. That was not the case in 2023. Rains were frequent and temperatures were cooler than usual into July. Some growers delayed planting waiting for temperatures to increase, while others took advantage of the moisture provided.

Overall, we started off the year with the best stands we have gotten in a long time. We then began to have stand losses from white-tailed deer feeding. When our April crop began squaring, we started to pick up some extremely high tarnished plant bug numbers as well. This, accompanied with the low temperatures experience through the early months of the summer, had some concerned our crop would be delayed. However, August came in with a vengeance. It became extremely hot and dry, almost like Mother Nature was trying to make up for lost time. This weather really punished our crop as a whole, in particular the southwest corner of Georgia. Towards the end of August, Hurricane Idalia made landfall and went over many cotton-producing counties, with the Lowndes, Brooks, Cook, and Berrien county area likely hit the hardest. For the rest of our state, that storm produced some damaging wind and significant rainfall (up to 10 in. in spots).

USDA predicts that Georgia growers will wind up harvesting 1,100,000 acres of cotton, which places Georgia as clearly the second largest cotton-producing state in the United States, second only to Texas. Georgia producers have long remained committed to planting cotton compared to other states across the belt, as Georgia had at least twice as many acres as every other cotton state.

Table 1. Average Acreage and Production in Georgia Since 1980.

Time Period	Planted Acreage (x 1,000 acres)	Yield (pounds/acre)	Total Bales (x 1,000 480-lb bales)
1980–1985	177	564	207
1986–1990	289	573	328
1991–1995	778	729	1,135
1996–2000	1,424	658	1,754
2001–2005	1,350	717	1,969
2006–2010	1,140	835	1,941
2011–2015	1,354	915	2,504
2016–2020	1,292	860	2,262
2021	1,170	914	2,210
2022	1,290	1,002	2,650
2023	1,110	1,025	2,350

USDA NASS Quick Stats. www.nass.usda.gov. 2022 information forecasted December 12, 2023.

Weather stations at each on-farm variety trial, as well as at the UGA Weather Monitoring network, recorded that from planting to harvest, there was between 20 to 30+ in. of rain accumulated.

Depending on location this could have been a couple of in. more than 2022, right on par with 2022, or up to 10 in. less than 2022. Although rainfall totals were slightly more variable, what was more critical in 2023 was the timing of rain events.

Our state as a whole had a hot and dry spell in late August, when the majority of our crop was at peak water demand. Depending on the area of the state, yields have been all over the board, which can be considered normal. Dryland suffered a little more than irrigated, depending on planting date and part of the state, which I would consider normal, but it has not been the case for the last few years.

Of course, there are exceptions to every rule, as the northern cotton-producing counties in Georgia (i.e. north of Macon) are majority dryland and are potentially looking at a record crop. The latest-planted cotton (June 10 and later) was knocked back by an early frost the week of October 23, which was the earliest frost in at least 20 years in

some places. Subsequent cold weather and frost/freeze events negatively impacted our late cotton crop. This is the second year in a row we have had an early frost in many areas of Georgia, which is something I am already talking with agents about as we approach planting in 2024. Overall, it seemed that, in 2022, yields were more impacted by irrigation and rainfall in the southern portion of the state, with higher yields reported in irrigated conditions compared to dryland in most cases.

The harvest season weather during 2023 has been incredible. In general, it felt as if cotton harvest fell behind due to delayed peanut maturity. However, we generally tracked with historic harvest trends. Weather conditions during harvest have contributed to outstanding fiber quality. At the time of this publication, not all ginnings are completed, but based on USDA estimates Georgia will produce a crop with an average yield of around 1,025 lb/acre, which would be the second highest lint yield in history.

The overall quality of the cotton crop in Georgia in 2023 could be considered good to excellent (Table 2). In Georgia, variety selection and harvest timing are the two main factors which impact fiber quality. Georgia producers continue to plant varieties that have high yield potential and great fiber quality, although some of the newer, higher yielding varieties may suffer relative to fiber quality. Thankfully, Georgia growers have not had many extraneous matter issues in 2023. Color grades have been phenomenal due to the incredible harvest weather we have had. Average micronaire was 4.45 and approximately 4% of bales were discounted for high levels. Fiber length averaged 36.25, which is down slightly from the previous three years. Fiber strength averaged 30.88, which is an improvement from the last two years. Uniformity is almost identical to what we saw in 2022. As mentioned earlier, these fiber quality parameters are a function of environment and variety. Fiber quality should be considered during variety selection decisions.

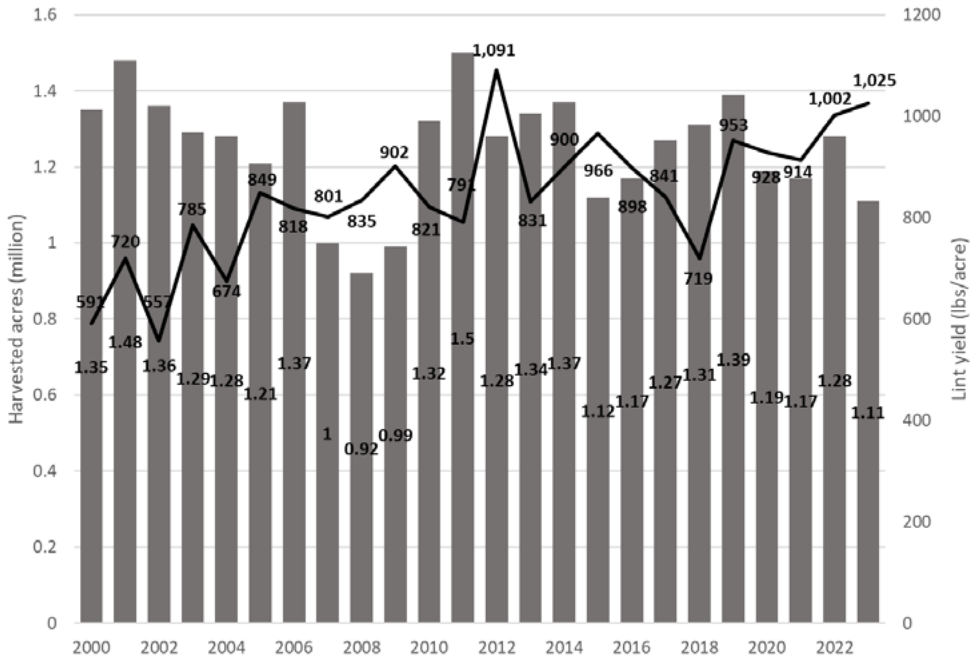


Figure 1. Georgia's state-wide average yield (lb/a) and harvested acres over the past 23 years. (USDA NASS)

Table 2. Fiber Quality of Bales Classed at the Macon USDA Closing Office, 2008–2023.

Year	Color Grade 31/41 or better (% of crop)	Bark/Grass/Prep (% of crop)	Stands (32nds)	Strength (g/tex)	Micronaire	Uniformity
2008	25 / 93	all < 1.0	34	28.7	4.6	80.2
2009	26 / 96	all < 1.0	35	28.8	4.5	80.3
2010	50 / 90	all < 1.0	35	29.9	4.8	81
2011	38 / 84	3.0 / < 1 / 1.0	36	29.6	4.6	81.7
2012	46 / 91	12.4 / < 1 / < 1	36	29.1	4.7	81.5
2013	57 / 98	5.7 / < 1 / < 1	35.9	29.7	4.8	81.7
2014	62 / 87	3.45 / < 1 / < 1	35.6	29	4.7	81.6
2015	16 / 54	2.3 / < 1 / < 1	36	29	4.7	81.3
2016	82 / 96	3.1 / < 1 / < 1	35.9	29.8	4.7	82
2017	59 / 97	5.0 / < 1 / < 1	37	29	4.4	82
2018	34 / 74	11.9 / < 0.05 / 0.1	36.6	28.8	4.3	81
2019	36 / 76	3.3 / 0.1 / < 0.05	36.5	30	4.5	81.6
2020	24 / 83	0.7 / < 0.05 / < 0.05	37.09	29.92	4.45	81.35
2021	41 / 89	0.8 / 0.1 / 1.9	36.65	29.83	4.29	81.06
2022	53 / 91	0.7 / 0.1 / < 0.05	36.55	30.24	4.31	81.22
2023	63 / 98	0.5 / 0.2 / < 0.05	36.25	30.88	4.45	81.33

Percent bales classed short staple (< 34) and high mic (> 4.9):
2008: 16 and 21
2009: 5 and 20
2010: 16 and 9
2011: 4 and 8.8
2012: 1.4 and 20.5
2013: 1.1 and 30.1
2014: 5 and 18.1
2015: 2 and 17.3
2016: 5 and 19
2017: 3 and 4
2018: 2 and 0.7
2019: 2.9 and 6
2020: 0.03 and 4.7
2021: 6.1 and 0.9
2022: 1.1 and 2.4
2023: 1.5 and 4.

Source: http://www.ams.usda.gov/aMSv1.0/

Note. Data for 2023 accounts for bales classed before 12/8/2023.

Economic Situation and 2024 Market Outlook

The cotton market in 2023 settled into its usual patterns following a tumultuous year in 2022. In 2023, cotton prices were driven by economic growth and cotton supply and demand situations as the usual patterns. Slower global economic growth resulted in lower cotton demand and lower prices. In addition, the appreciation of the U.S. dollar and the high interest rate further discouraged cotton prices. Cotton supply was also reduced due to lower prices, resulting in the equilibrium of cotton prices from upper 70 cents per lb to a lower 80 cents per lb during harvesting season in 2023.

Many people wonder when cotton prices will surpass the one-dollar mark again. Predicting the future is tricky, and while past trends do not guarantee future outcomes, they offer some insights. Over the last two decades (Figure 2), only two years saw cotton prices go above a dollar: 2011 and 2022. Both these periods were influenced by unique circumstances. In 2011, China's support programs boosted prices as state-owned enterprises purchased large quantities of cotton to aid Chinese cotton producers. In 2022, high prices resulted from speculative purchases of cotton futures, disruptions in global agriculture supply chains negatively shocked cotton supply within a short period, and severe drought in the Southwest United States and flooding issues in Asia production regions reduced cotton supply. Chances that we would experience again these unique circumstances as in 2011 and 2022 are low. This offers us some expectations about where the cotton prices will be headed in 2024.

Figure 2. Cotton Cash Prices for the Past Two Decades. Source: barchart.com.

Economic Slowdown and Reduction in Cotton Demand Globally

Looking ahead, the year 2024 could be another challenging year for cotton producers. According to the International Monetary Fund World Economic Outlook report in October 2023, global recovery remains slow. Global economic growth is expected to slow from 3.5 percent in 2022 to 3.0 percent in 2023 and 2.9 percent in 2024, well below the historical (2000–19) average of 3.8 percent. For the advanced economies, where the highest demand for cotton related products comes from, economic growth is expected to slow even further from 2.6 percent in 2022 to 1.5 percent in 2023 and 1.4 percent in 2024.

Globally, 2023 cotton production is projected at 113.4 million bales, below the world cotton mill use at 115.3 million bales (Figure 3). Uncertainties about the world economy and competition from synthetic fibers are

forecasted to limit global cotton mill use growth, according to the U.S. Department of Agriculture. The reduction in economic activity would likely continue to reduce consumer demand for discretionary items, such as textiles and apparel, thus suppressing cotton prices in 2024. The cotton production profit margin would likely be lower, with input costs remaining at a relatively high level.

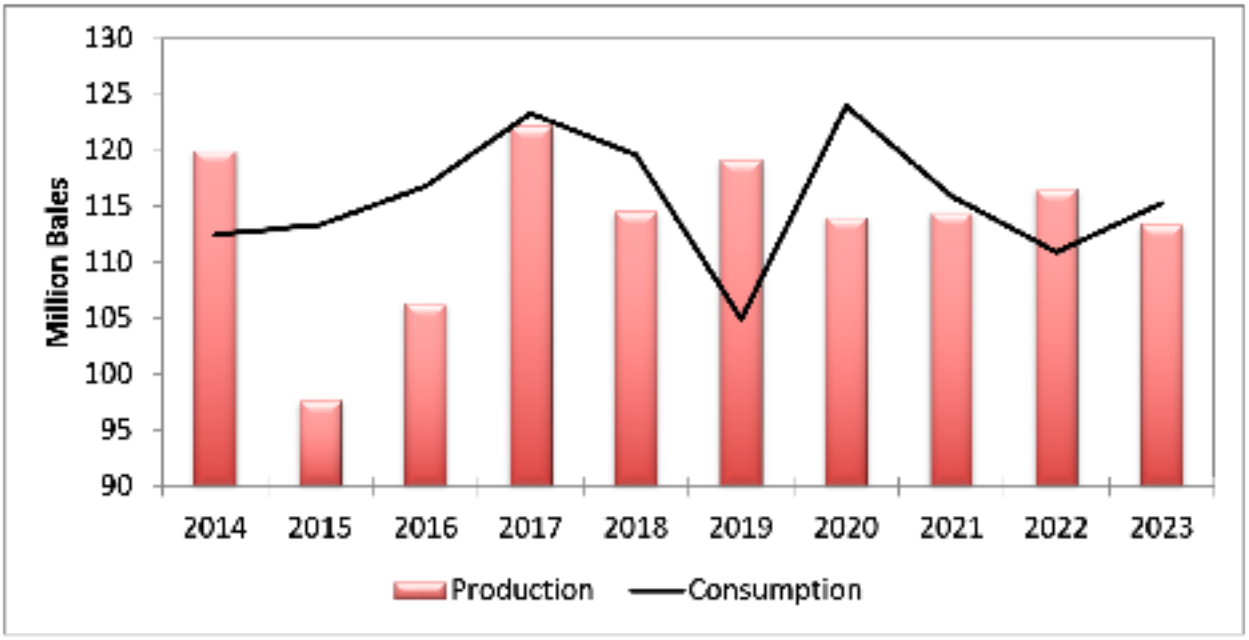


Figure 3. World Cotton Supply and Demand. Data source: USDA FAS.

U.S. Cotton Supply and Demand

In 2023, the U.S. planted 10.1 million acres of upland cotton, the lowest since 2016. U.S. upland cotton production at 12.7 million bales, nearly 1.3 million bales below the 2022/23 crop, and the lowest since 2015. The harvested area in 2023/24 is projected to be 7.9 million acres, higher than last season, but it remains the second lowest over the past decade. The national yield is projected at 776 lb per acre, noticeably lower than the 2022 crop at 942 lb per acre.

The U.S. cotton demand estimate for 2023/24 is projected at 14.3 million bales, nearly 0.5 million bales below 2022/23, as the smaller crop limits demand prospects. Due to lower production, U.S. ending stocks are projected at 3.2 million bales in 2023. The U.S. ending stocks-to-use ratio is forecast at 22.5 percent for the 2023/24 marketing year.

Inflation Rate, Interest Rate, and U.S. Dollar Appreciation

In response to high inflation, the Federal Reserve increased the federal funds rate to tamp inflation with its largest rate increase since the 1980s. The Federal Reserve's commitment to bringing inflation back down to its target of 2% resulted in a 5.5% target rate for federal funds by the end of the year in 2023. With the recent upticks in the inflation rate (Figure 4), it remains uncertain when the Fed might begin to cut interest rates. Cotton producers must continue their debt management to cope with the high interest costs in 2024.

Meanwhile, the rising interest rate resulted in the appreciation of the U.S. dollar. Cotton is a global commodity; on average, over 80% of cotton produced in the U.S. is exported. The appreciation of the U.S. dollar increases prices paid by foreign consumers and makes U.S. cotton less attractive. This could put further pressure on cotton prices for U.S. producers in 2024.

Figure 4. Inflation Rate (Consumer Price Index) in the U.S. for the past 20 years. Source: U.S. Bureau of Labor Statistics.

Georgia Situation

Georgia planted 1.11 million acres and is projected to harvest 1.1 million acres in 2023, with an estimated 2.35 million bales of cotton produced in 2023. The average cotton yield in Georgia is 1,025 lb per acre, the highest yield for the past decade and the second highest on record after 2012.

2024 Price Outlook Summary

If we call the year 2023 a challenging year for cotton producers, 2024 could be even tougher. Monetary policy is expected to remain tight for a period of time until inflation is stabilized. Consumer spending on discretionary items is expected to tighten up with slow economic growth and lower saving rates. Input costs remain at a relatively high level, and cotton producers face downward pressure on cotton prices. U.S. cotton acreage and production would be likely to continue to decline in 2024 due to lower relative price expectations with competing crops, such as peanut and corn.

The optimistic likely price for cotton in 2024 is 79 to 83 cents per lb or better, and the pessimistic likely price for 2024 is 69 to 73 cents per lb. For planning and budgeting projections, a price of 74 to 78 cents per lb is suggested for 2024. Producers who are not in a marketing pool are encouraged to develop a marketing plan to protect the harvest price, as it is risky to lock in high input prices without a marketing plan for the crop. Higher production costs and greater financial risk in 2024 make it more critical for producers to estimate and control their cost of production.

FERTILIZATION

Lime

The official UGA recommendation or "target" soil pH (measured in 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 (one composite sample per field) are encouraged to maintain their soil pH for cotton between 6.0 and 6.3. **Soil sampling on 2.5-acre grids are encouraged, especially in newly cropped fields or where large areas of fields that have been traditionally sampled have been diagnosed with soil pH problems. Recent soil sampling research on different grid sizes has suggested that grids larger than 2.5 acres (including 5-acre grids, which are commonly used in Georgia) are not effective in detecting spatial nutrient variability (soil pH, P and K) and mostly results in considerable under- or over-application within the fields.** 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 the 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.

Many factors that affect the 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.

Another sampling variable (in addition to spatial and depth) is temporal variation. Soil pH can vary naturally over the course of a calendar year due to the salt concentration in the soil and how the pH is measured. **Most private labs and university labs, with the exception of the UGA Soil testing Lab, measure soil pH in water (1:1 soil to water volume). Since salts tend to leach out of our sandy Coastal Plain soil in winter (January–March) this can lead to "false high" soil pHs.** While this problem does not appear to be widespread, it does appear to be occurring more in recent years. Since January-March is a popular time frame to take soil samples in Georgia, if results from a soil sample show a field rising in pH compared to results taken the previous year, and especially if the rise in pH is more than 0.5 units and no lime was applied, then this result should be considered suspect. Since it will take time for the salts to re-accumulate and get an accurate measurement using the "water" method, either wait a few months to resample or have the sample run in dilute salt, the method currently used at the UGA Soil Testing Lab.

Dolomitic lime (with 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.

If a low soil pH (below 6.0) is confirmed with soil testing close to cotton planting time or soon after planting (2 or 3 weeks) it is still advised to apply lime. Regular ground or fine lime (liquid or solids) can be used at this time. There are enough fine (smaller) particles even in regular ground lime to start bringing the soil pH up and recue the crop in most cases.

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. 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 side dress, have also not proven to be effective. In fact, in some cases this approach may lead to potassium deficiency before side dress applications are made. Recent field trials conducted in Georgia have focused on additional soil-applied K during N side dressing 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 side dress 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 in. 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 lb/K_2O in each application during early bloom (the first 4 weeks 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 therefore should not be applied in the Fall either. 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 applied on cotton, yet it is the most difficult to manage. Low N rates can reduce yield and quality while excessive N rates can cause rank growth, boll rot, delayed maturity, difficult defoliation, and poor quality and yield. Total N rates for cotton should be based on soil type, previous crop, growth history, and yield potential. Base N rates recommended by the UGA Soil Testing Lab according to yield goals are listed below.

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

Increase N rate by 25% if:

- Deep sandy soil
- Cotton follows cotton
- History of inadequate stalk growth

Decrease N rate by 25% if:

- Cotton follows peanuts or soybeans
- Cotton follows good stands of winter legumes such as clover or vetch
- History of rank or excessive vegetative growth

Yield goals should always be realistic, preferably based on past production records. For N rates above 120 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 also assume irrigation.

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

The total N rate should always be applied in split applications. Apply ¼ to ⅓ of the recommended N at planting and the remainder at side dress. 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. Side dress 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 side dress 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 third week of bloom**. Studies have shown that uptake of soil-applied N by cotton roots is basically ineffective after this critical timing point.

There are a number of side dress 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 side dress 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 popular liquid side dress N source for Georgia 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 basically "liquid ammonium nitrate and sodium nitrate" (approximately 60% nitrate and 40% ammonium with no urea). Replicated, small plot research trials conducted between 2010 and 2012 indicated that 18-0-0-3(S) is comparable to 28-0-0-5(S) in terms of producing cotton yield. For foliar feeding N, feed grade urea is still the product of choice in terms of performance and cost. 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 side dress 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. Recent field studies in Georgia have indicated that a severe sulfur deficiency will decrease cotton yields by approximately 500 lb of lint per acre.

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 or being washed off by a rain event soon after application. 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 side dress soil applications can also be considered effective. If no B is included in preplant, starter, or side dress 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 in Georgia 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 in cotton, minimum levels of soil test manganese should be maintained with varying pH levels as shown in Figure 5.

Notice on the graph, that if soil pH is at the recommended target of 6.0, the 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.

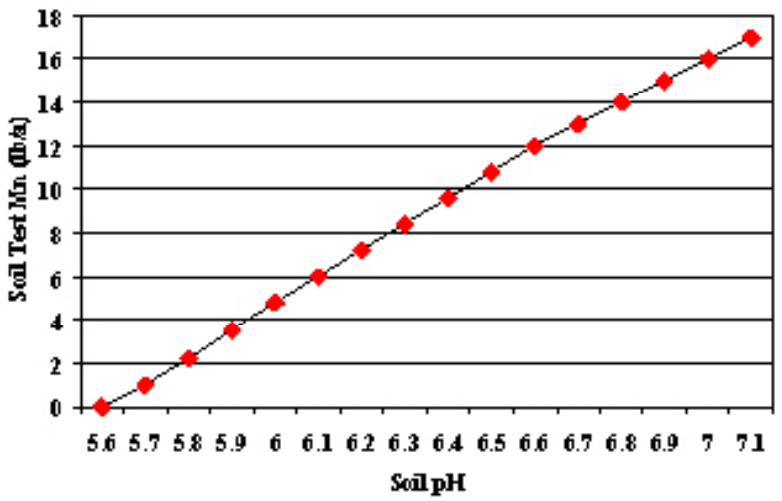


Figure 5. Relationship between pH and managenese availability. Maintain soil test manganese levels above the line to help avoid managenese deficiency. Source: Soil Test Handbook for Georgia.

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

Large amounts of soil applied Mn (above 5 lb/a) are not considered to be economical. Therefore, in situations where soil test levels of Mn need to be built up, do so slowly and monitor the crop for deficiency using tissue testing. In essence, if a grower prefers to maintain a 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 prefers to maintain a 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 (using 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 UGA and 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 times during the fruiting period as desired. Simply sample the petioles and send them to the UGA 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 testing can also be used any time during the growing season when trouble shooting. The tissue samples should be taken from both normal ("good") and affected ("bad") areas of the field.

Since petiole and tissue samples provide different information, 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 the total N in a petiole cannot be interpreted since no correlation 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 the 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 (5 gal/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. Potassium nitrate is the most common material used for foliar K applications. The standard recommendation is for 4.4 lb K2O/a in 5 gal or more of water. Again, 5 gal/a assumes aerial application and both liquid and granular KNO3 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 5th–7th week of bloom may or may not be effective depending on the particular cotton variety grown. How late is too late to foliar feed cotton? Once you pass the 8th 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 in. below and 2 in. 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 in order to decrease any chance of fertilizer burn and stand reduction of stand. "Dribbling" liquid starter fertilizers on the soil surface, 2 in. 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 in.) 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, the dollar value of a ton of chicken litter varies year to year mostly due to changing fertilizer prices. For example, since broiler litter has an approximate analysis equivalent to 3-3-2 (%N –% P2O -% K2O), one ton of broiler litter contains on average 60 lb/a of N, 60 lb/a of P2O and 40 lb/a of K2O. Based on current (2022) record-high fertilizer prices for N, P, and K , poultry litter may be valued as high as $90/ton. If soil test P levels are high

and no fertilizer P is recommended, since approximately 1/3 of this total value is for P, then chicken litter would only be valued around $60 per ton. In addition, this value 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 side dressing. For example, 2 ton/a of poultry litter preplant incorporated followed by 30 to 60 lb/a of side dress 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. Buildup 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 (such as wood ash). 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. Preferably, whoever is responsible for making the by-product available for land application should also have it field tested by an unbiased third party. This is actually required in order to have any by-product approved and registered by the Department of Agriculture as a fertilizer, lime, or soil amendment which is also required by law. Since every by-product is unique, they should be investigated on an individual case-by-case basis.

Soil Health

Soil health and carbon sequestration have become important buzz phrases in recent years. This is largely because of the increased awareness of climate change and the imminent threats. The steady rise in atmospheric CO2 levels is deeply concerning because CO2 is a greenhouse gas that absorbs longwave infrared radiation reflected from the earth's surface. The process heats the lower atmosphere, causing adverse weather impacts, such as drought and wildfire activities, extreme heat events, heavy precipitations, floodings, and tropical storm activities. As a global issue, there have been increased policy incentives to support growers because the agricultural sector can contribute tremendously to climate change abatement efforts. For instance, the adoption of efficient practices that minimize dependency on fossil fuel and energy, as well as regenerative agricultural practices that help to increase soil carbon, are all important contributions growers make.

Increased soil carbon and overall soil health would also be of value to growers because they can improve the productivity and resilience of farming systems. Nonetheless, some of the management practices will substantially increase the production cost of growers, and soil health and carbon sequestration are slow processes, taking as much as 10 years to observe remarkable improvement. It is important to recognize that farming is a business enterprise. Growers cannot continue to farm without economic profit. Therefore, it is recommended that efforts to increase soil carbon and overall soil health must also sustain or increase productivity and economic profitability in the short and long term.

According to the USDA-NRCS, soil health is defined as the continued capacity of soil to function as a vital living ecosystem that sustains plants, animals, and humans. From a crop production perspective, soil serves various functions, including providing physical support to the crop, recycling nutrients, regulating water flow and storage, and being a habitat for several micro and macro fauna beneficial for plant growth. Given the critical functions that soil plays in crop production, it is logical to expect that improved soil health will correspondingly lead to improved crop productivity. Soil health can be assessed by measuring different physical, chemical, and biological soil properties.

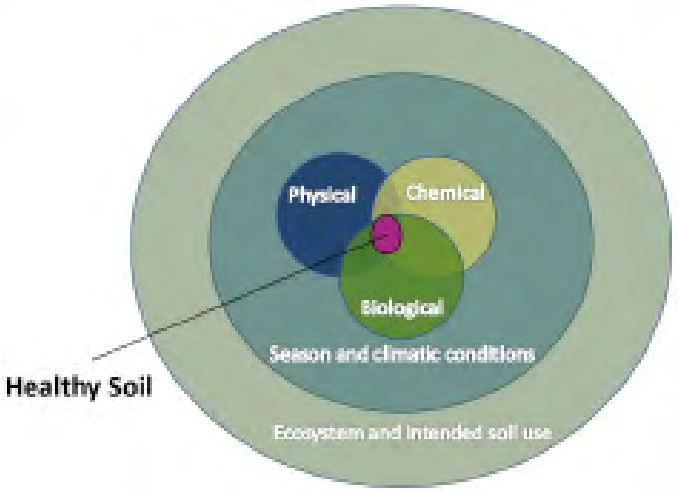


Figure 6. Schematic showing healthy soil is based on the interaction of physical, chemical, and biological properties within a specified ecosystem and intended soil use, as well as season and climatic conditions. From Sintim et al. (2022), https://doi.org/10.3389/fsufs.2022.1055636.

For instance, while a soil pH of 6 to 7 is suitable for several crops, including cotton, there are soil-acidic-loving crops, such as blueberries. Thus, soils with a pH of 6 to 7 may not be considered healthy for blueberry plantations, highlighting the need to interpret soil health based on its capacity to function in a given context. As already mentioned, extensive research has been conducted to determine the best levels of the soil properties. The levels of the soil properties for plant growth can be presented as index scores, where there are ratings (on a percent scale) based on the soil property values. In general, there are three types of index scores: (a) more is better, (b) less is better, and (c) optimum range. The "more is better" score is used when a higher value of the soil property indicates improved soil health. Examples include organic matter, aggregate stability, and water infiltration. On the other hand, the "less is better" score is used when a higher value of the soil property indicates poor soil health. Examples include electrical conductivity (salinity), soil sodicity (dispersion), and C:N ratio. The optimum range is used when a higher value of the soil property indicates improved soil health up to an optimal level, and then a further increase in the soil property becomes harmful. Examples include soil pH, bulk density, and soil porosity. In Figure 7 are examples of the three types of soil index scores. Research is currently

ongoing to establish the index scores for cotton production in Georgia. Extensive research has been conducted to determine the best levels of soil properties for plant growth, and the levels vary for different crops and locations. Thus, soil health must be interpreted based on ecosystem and intended soil use, as well as the season and climatic conditions as shown below.

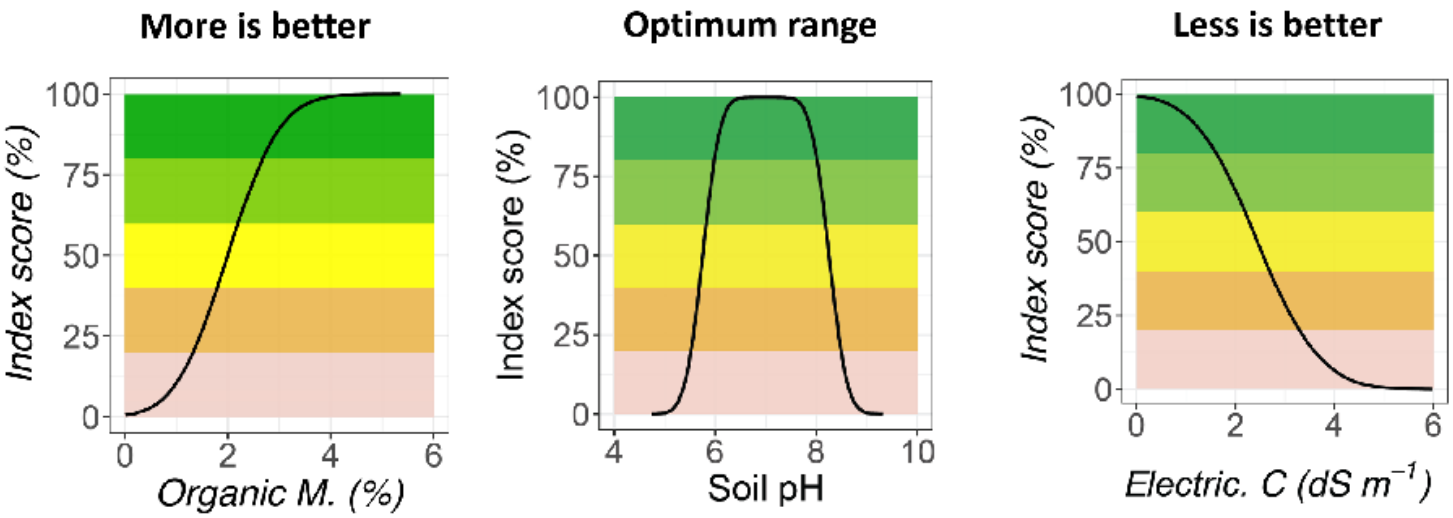


Figure 7. The three types of index scores used to assess soil properties. From Sintim et al. (2019), https://doi.org/10.1016/j.agee.2018.12.002.

Soil Carbon Sequestration

The term carbon sequestration is defined in the Sixth Assessment Report of the United Nations (UN) Intergovernmental Panel on Climate Change (IPCC) as "The process of storing carbon in a carbon pool." The UN-IPCC also defined a pool as "A reservoir in the Earth system where elements, such as carbon and nitrogen, reside in various chemical forms for a period of time." Thus, soil carbon sequestration can simply be defined as the process of storing carbon in the soil. It was estimated that the soil contains about 80% (2,500 GT) of the total terrestrial carbon (3,170 GT). The atmosphere had far less carbon (800 GT), and this highlights the potential climate change impact if the soil is not well managed and is allowed to lose a significant portion of its carbon. Unfortunately, about 130 GT of carbon has been lost from the soil in the last 200 years. The mass of carbon is 27.27% of the total mass of CO2. By conversion, 1 ton of carbon loss in the soil is equivalent to 3.67 tons of CO2 added to the atmosphere, assuming oxygen is not limiting.

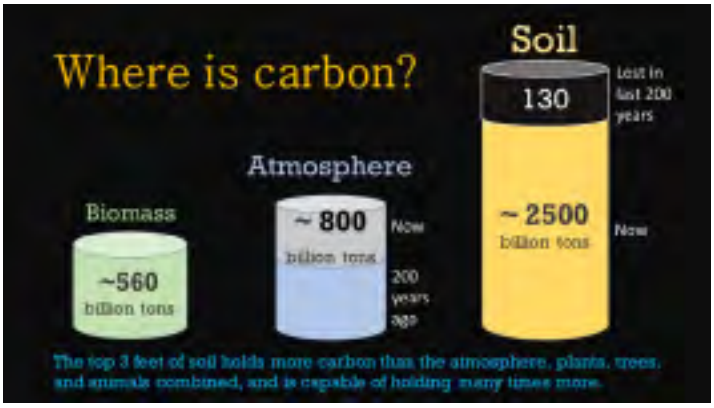


Figure 8. Carbon levels in biomass, atmosphere, and soil. Note that 1 GT is equivalent to 1 petagram or 1 billion metric tons or 1.102 billion US tons. Figure credit to Erik Swartzendruber of Benton Soil and Water Conservation District, Corvallis, OR.

Management Practices

Management practices to improve soil health tend to also increase soil carbon. It is important to note, however, that not all soil properties can be affected by management practices. Soil properties that are not affected by management practices are considered inherent or use-invariant properties, and they include soil texture and

the type of clay. They are affected by soil-forming factors such as climate, parent material, time, and biota. The soil properties that are affected by management practices are considered dynamic or use-dependent properties. Examples include soil structure, infiltration, and organic matter, and they can be considered as aggrading, sustaining, or degrading over time as depicted below.

The principles to manage and improve soil health include minimizing soil disturbance, maximizing biodiversity, maximizing soil cover, and maximizing living roots. As already mentioned, farming is a business enterprise, and therefore, it is recommended that efforts to increase soil carbon and overall soil health must also sustain or increase productivity and economic profitability in the short and long term. For cotton production in Georgia, research has shown the use of poultry litter, conservation tillage, and cover crops to satisfy the recommendation. These production practices are discussed at length throughout this production guide.

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 9). Weeds also may interfere more with harvesting of cotton and can reduce lint quality because of trash or stain. *Implementing sound strategic weed management programs across the farm are critical for not only controlling troublesome weeds but also minimizing resistance and regulatory challenges which are at the forefront of agriculture today.*

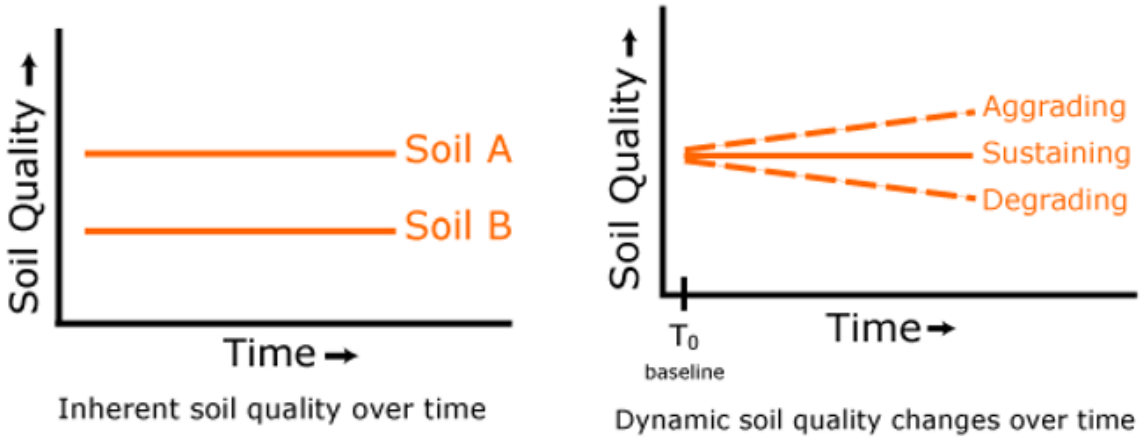


Figure 9. Depiction of inherent and dynamic soil properties and how they change over time. From Andrews and Wander, 2011, http://www.soilquality.org/basics/inherent_dynamic.html.

CROP ROTATION

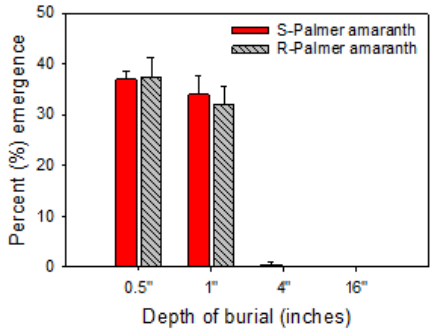
Crop rotation aids in the management of nematodes and diseases and is often critical in delaying herbicide resistance and improving weed control. It also enhances the opportunity for improved diversity in management tactics, including using herbicides with different modes of action on the same field across 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.

One must carefully select herbicides used in the crop preceding cotton making certain those products do not carryover and harm the cotton crop. 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.

Similarly, cotton herbicides such as Cotoran, diuron, Envoke, fomesafen (Reflex, other), and Staple have significant rotational restrictions to some commonly grown crops. Thus, one needs to carefully consider which herbicides are to be applied in cotton avoiding damage to the following crop.

TILLAGE

Deep Turning: This practice can assist in the management of certain insects and diseases while improving the control of many weed species, especially small-seeded weeds. For success, it is critical to understand the biology of the weedy pest that one is attempting to manage. For example, research notes Palmer amaranth rarely emerges from depths below 4 in. (Figure 10). Thus, seeds buried to a depth of at least 4 in. will not emerge, *improving weed control and resistance management* (Figure 11). Recent research on annual ryegrass has noted this weed responds similarly to Palmer amaranth in regards to deep turning. It is important to note that the lifespan of the seed in question is critical in determining the interval needed before implementing deep turning again.



Keeley et al. (1987) reported 36-44% emergence at 0-1", 7% at 2", and 2% at 3".

Figure 10. Influence of Burial Depth on Palmer Amaranth Emergence.

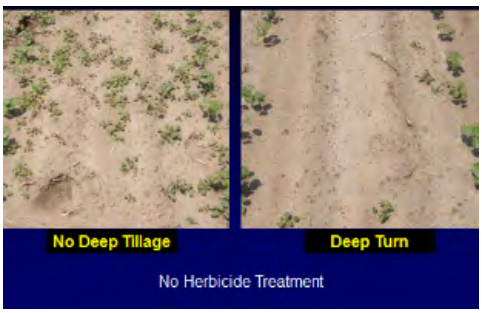


Figure 11. Number of Palmer Amaranth Plant During Early Season. Macon County, GA 2008.

Cultivation

Most cultivation disappeared with the adoption of Roundup Ready Technology in the late 1990s until glyphosate-resistant Palmer amaranth forced some growers back to plowing from 2005 through 2015. The adoption of technologies tolerant to glufosinate (Liberty, etc.), dicamba, and 2,4-D have allowed growers to once again eliminate cultivation for all practical purposes.

Cultivation can be used to effectively manage small weeds between cotton rows. Cultivate prior to most weeds reaching 3 in. and tropical spiderwort reaching 2 in. Also, if possible, avoid rainfall or irrigation for at least 48 hours after cultivating. This practice will likely destroy any residual herbicides present; thus, the application of a residual herbicide immediately after the last cultivation for the season may prove beneficial. Cultivation can be an effective component of a 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 often reduces the following: equipment and labor demands, subsequent weed flushes, destruction of residual herbicide activity, moisture loss, and crop root damage occasionally associated with the practice.

COVER CROPS

Like never before, herbicide resistance threatens the sustainability of our family farms. If managed properly, cover crops have the potential to greatly reduce herbicide selection pressure for many weeds thereby extending the longevity of herbicide use. Research shows an effectively grown grain cover crop that is rolled prior to planting can reduce Palmer amaranth emergence 65 to 90%. Control is not a result of allelopathy but rather from the impact of blocking the sunlight from reaching the soil and/or simply serving as a mulching effect. In general, the greater the level of biomass and the greater the length of stability of that biomass, then the greater weed

suppression will be observed. In nearly all fields infested with Palmer amaranth, an herbicide program will be needed in conjunction with the cover crop for long-term success. A DVD on this system was created many years ago but may still be helpful. The herbicide programs have changed drastically since the DVD was created but the concepts remain viable: https://www.youtube.com/watch?v=F0VTHsRO_0Q&feature=youtu.be.

Cover crops also offer an opportunity to reduce the movement of water, pesticides, and soil from a field. This practice is likely to become extremely valuable when regulations as influenced by the Endangered Species Act are implemented on all pesticide labels.

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 as well as pesticide application equipment, 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 more likely severe crop injury. Herbicide rates for control of emerged weeds are usually determined by weed size.

Weed Mapping. The first step for a successful weed management program is to identify the problem which is best accomplished by weed mapping. Survey fields each fall, documenting species and population levels present on a field map. Species present in the fall will likely be the predominant problems during the following year. Knowing which species are likely to occur will allow one to develop a more effective herbicide program. Additionally, by referring to weed maps over a period of two or three years, one can detect shifts in the weed populations and make adjustments in the herbicide program. 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.

Active Ingredient	Examples of a few of the products containing the active ingredient
diclosulam	Strongarm
imazapic	Cadre, Impose, Nufarm, Imazapic
imazethapyr	Authority Assist, Extreme, Lightning, Matador, Optill, Pursuit, Thunder, Thunder Master
sulfentrazone	Authority Assist, Authority First, Authority Maxx, Authority MTZ, Authority XL, Blanket, Broadaxe, Sonic, Spartan, Spartan Charge, Spartan Elite, Sulfentrazone, Zeus

HERBICIDE RESISTANCE MANAGEMENT

Herbicide resistance in weeds is not a new problem. However, the threat posed by herbicide resistance has been elevated in recent years. Palmer amaranth resistant to glyphosate (Roundup), ALS-herbicides (Staple, Envoke, Cadre), DNA-herbicides (Treflan, Prowl), and/or atrazine have been confirmed to infest numerous Georgia agronomic producing counties. In 2020, Palmer amaranth resistance to POST applied PPO herbicides (Reflex,

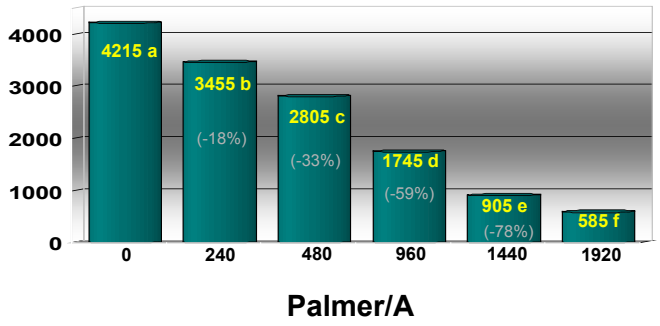


Figure 12. Irrigated Cotton Seed Yield vs. Glyphosate-Resistant Palmer Amaranth Density.

Ultra Blazer, and Cobra) was confirmed in Georgia (Figure 12) and during 2022 Palmer amaranth resistant to the residual activity of Reflex and Valor was confirmed. Also of importance, common ragweed, goosegrass, horseweed, johnsongrass, and ryegrass resistant to Roundup are scattered across the country.

In the past, 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; thus, it is imperative that growers take herbicide resistance management very seriously and 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 that is 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. Additionally, applying sub-lethal herbicide rates or making untimely herbicide applications can foster the development of resistance.

Resistance Management Strategies. There are two prerequisites for resistance. First, one or more individuals possessing genes conferring resistance must be present in the population. Second, selection pressure resulting from 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 continues to dominate the landscape.

It is absolutely essential that herbicide programs 1) are integrated with other cultural control practices (hand-weeding, tillage, cover crops, crop rotation, etc.), 2) are diverse in herbicide modes of action, and 3) are implemented in a timely manner maximizing activity thereby reducing herbicide selection for resistant weeds. Incorporating diversity in herbicide modes of action into a management program can be achieved by using soil-applied residual herbicides at planting and throughout the season, tank-mixing herbicides, and using conventional chemistry such as diuron as a layby directed treatment.

ON-TARGET PESTICIDE APPLICATIONS ARE CRITICAL FOR SUSTAINABILITY

Science is clear that pesticides are currently essential for U.S. farmers to be able to feed and clothe the world. However, it is critical and will become even more important that pesticides are used judiciously and carefully to protect the user, the consumer, the environment, and our wildlife. Several of the greatest regulatory challenges facing family farms today include the following: 1) the Endangered Species Act, 2) protecting pollinators, 3) pesticide resistance management, and 4) pesticide drift. The most important approach to overcome each of these challenges is to ensure pesticide applications are made on-target within an integrated and diversified management approach. A joint partnership between The University of Georgia and The Georgia Department of Agriculture called Using Pesticides Wisely (UPW) has been developed to provide the latest science helping applicators make the best decisions possible when using pesticides.

MANAGING COMMON/TROUBLESOME WEEDS BEFORE PLANTING

Note: Check herbicide planting intervals restrictions before use.

Cover crops can be extremely effective reducing emergence of some weeds, especially Palmer amaranth, but some cover crops require a significant effort to kill. Small grains can usually be controlled easily with Roundup, although the herbicide does not perform well during cold conditions and grains (especially wheat) are usually more tolerant at the jointing through boot stages of growth. Additionally, once grains have mature seed, paraquat is very effective. *Of great importance, using ryegrass as a cover crop that is to be controlled with herbicides is strongly discouraged because of rapid resistance development.* For clover, dicamba and glufosinate (Liberty) mixtures are very effective. Roundup + dicamba or 2,4-D are very good options for vetch.

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, but growers should consider their equipment capabilities for strip-tilling and planting into residue when deciding the ideal time to terminate a cover crop. For growers planting into weeds, burndown should occur a minimum of 14 days before planting. Burndown herbicides are outlined in the "cotton weed control" appendix.

Cutleaf eveningprimrose and wild radish have traditionally been troublesome 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 12 oz/a of a 3.8 lb/gal formulation mixed with Roundup is sufficient and would reduce the interval between application and planting non-Enlist cotton cultivars; however, rates of 1.0 to 1.5 pt/a are needed for wild radish. Dicamba will also provide good primrose control when mixed with Roundup; dicamba is not very effective on radish.

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 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 paraquat plus Direx.

Glyphosate-Resistant Horseweed or Fleabane: Glyphosate-resistant horseweed (also called marestail) and fleabane are common as seeds are easily spread by wind and equipment. These weeds germinate primarily in the fall, but additional plants may emerge in late spring. Plants emerging in the fall will be in a rosette stage and large enough for easy identification by early winter.

An early preplant burndown program is encouraged. Glyphosate-resistant horseweed and fleabane can be controlled by tank mixes of glyphosate plus 0.95 lb a.e./a of 2,4-D (2 pt/a of 3.8 lb a.e./gal formulation) or 0.5 lb a.e./a of dicamba (Engenia 12.8 fl oz or XtendiMax 22 fl oz). The addition of flumioxazin (Valor, others) in Roundup + 2,4-D or dicamba mixtures is suggested to provide residual control of these and other troublesome weeds. Mixtures with dicamba may perform more consistently than 2,4-D mixtures, although 2,4-D has typically worked well. Application in February (South GA) and March (North GA) is recommended. Control failures are usually related to later applications when the weed is too large.

Cotoran applied preemergence is a good option to control late-emerging horseweed; paraquat should be included with the Cotoran to kill emerged weeds.

In emerged cotton, several options do exist to control horseweed or fleabane. Enlist One plus Liberty or Roundup, Roundup plus Engenia or XtendiMax, or Tavium can be effective options in their appropriate varieties.

Liberty can also be used to manage horseweed if applied when daytime temperatures exceed 85 °F, although less effective than 2,4-D or dicamba mixtures.

Palmer amaranth is by far the most problematic weed of cotton and it is essential that no Palmer amaranth be emerged at planting. Herbicides, cover crops, and tillage are options to achieve this goal.

For conservation tillage, the use of Valor and/or Direx preplant is critical. Valor is the most effective residual herbicide while Direx plus paraquat offers the most effective control of emerged plants (Table 3). Neither 2,4-D nor dicamba are that effective in controlling Palmer with a single application; especially when compared to Valor (before Palmer emerges) or paraquat + Direx once it has emerged. *Make certain to follow the correct plant back interval* (Table 4).

Figure 13. Palmer Amaranth Response to PPO Herbicides Post.

Table 3. The Most Effective Options to Eliminate Emerged Palmer Amaranth Before Planting.

CONSERVATION TILLAGE - STRIP TILL		
Option 1	**Option 2**	**Option 3**
Valor with glyphosate or paraquat *(Palmer < 1" and 7 or more d before planting)*	**Valor + Direx + paraquat** *(Palmer ≤ 5" and 7 or more d before planting)*	**Direx + paraquat** *(Palmer ≤ 5" and less than 10 d before planting)*

Table 4. Plant Back Intervalsd for Valor or Direx Applied at Burndown.

Herbicide	Time Interval Before Planting	Special Comments
Valor	**In strip-till,** where the strip till rig (including ripper shank) is run after application and before planting. 1) > 30% ground cover = 7 days 2) 10-30% ground cover = 14 days plus 0.5" rain/irrigation 3) <10% ground cover = 21 days plus 1.0" rain/irrigation **In no-tillage production** or when the strip is implemented prior to application. Valor plant-back interval should be 28 days AND 0.5" (>10% ground cover) or 1" (<10% ground cover) rainfall/irrigation is required.	Do not exceed 2 oz/a if planting within 30 days. *If Reflex (or generic) will be applied PRE, data suggests an additional 7 days to planting intervals.*
Direx	no till: 7 d strip till after application and before planting: 0 d	Do not exceed 1 qt/a, see label for rate on your soil.

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 5) with the rest of the Reflex plus another residual herbicide applied preemergence right after planting.

SELECTING A PREEMERGENCE (PRE) HERBICIDE – ALL COTTON CULTIVARS

Residual at-plant herbicides are needed in all Georgia fields and for all crops including cotton. The lack of new herbicide chemistry along with the overuse of some herbicides has led to serious issues in the development of

Table 5. The Most Effective Options to Eliminate Emerged Palmer Before Planting in Conventional Tillage Systems.

Option 1	Option 2
Reflex 8-12 oz/a + Prowl/Treflan *preplant incorporated 2 in. deep (preferably within 24 hours of planting).* ***The addition of a preemergence herbicide is critical.***	**Keep clean with tillage or burndown herbicides**

Table 6. Most Effective Herbicide Options to Apply Preemergence (PRE) in Cotton.

Preemergence Option	Comments
1. Warrant + Reflex	Cotoran can be used to effectively replace Direx in fields with minimal Palmer infestations or for improved control of other broadleaf weeds.
2. Direx + Reflex	Use 10–12 oz/a PRE of Reflex for most soil types.
3. Warrant + Direx	Warrant rate suggested by the manufacture is 48 oz/a; UGA research suggest in a Liberty or auxin-based systems that 32 oz/a is often more appropriate.
4. Brake + Reflex	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 + Warrant	Brake requires 0.5 in. rain/irrigation to become active.

herbicide resistance. Applying effective residual herbicides behind the planter is among the most important management approaches to mitigate resistance development and to maximize yield potential.

Research consistently shows maximum control is achieved with two effective residual herbicides applied in mixture within 24 hours of planting; include paraquat if Palmer is up. Georgia research has shown Warrant + Reflex, Direx + Reflex, Warrant + Direx, and Brake + Reflex or Warrant to be consistently effective (Table 6).

Reflex (fomesafen) tank mixtures are currently the most common approach for residual Palmer amaranth control. It requires very little rainfall/irrigation to activate, often activated with 0.3 in., and Reflex 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 the following: 1) Warrant offers more residual Palmer and spiderwort 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. A three-way combination of Reflex plus Warrant plus Direx usually only provides better control than the two-way combinations if very low rates are used or emerged weeds are present.

Brake tank mixtures are also extremely effective once Brake is activated with at least 0.5 in. rainfall/irrigation. Additionally, for the grower frustrated with Reflex injury, a mixture of Warrant + Direx has proven effective in a "good" weed management system. Always include paraquat + adjuvant with the PRE if weeds are emerged.

Replanting after the PRE

If previously used herbicides do not pose an injury risk, it is best to run the planter back in the original drill without any soil preparation to preserve current herbicide efficacy, if conditions permit. If reworking the seedbed is necessary, 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 POST application may need to be made quickly.

Conventional Tillage: For those who do not have strip-tillage implements, using shallow tillage such as a light disking can be helpful. 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.

Killing emerged cotton: Roundup, paraquat, Aim, and/or Liberty are encouraged to control emerged weeds and cotton when replanting. Paraquat or Aim will control small emerged cotton. Liberty is also effective controlling cotton as long as it is not a cultivar tolerant to Liberty.

GLYPHOSATE (ROUNDUP) ALONE OR IN MIXTURES FOR TOLERANT COTTON

Most cotton cultivars now have tolerance to glyphosate; be certain the cultivars treated with glyphosate are tolerant or extreme damage will occur. Many brand names and formulations of glyphosate are available. Products vary in their concentration of active ingredient and their need for an adjuvant. Follow label recommendations.

Timing of Application

Brands of glyphosate with specific labeling for RR Flex cotton may be applied overtop or directed any time from cotton emergence until seven days prior to harvest. The maximum rate for any single application between crop emergence and the 60 percent open boll stage is 1.13 lb a.e./a. A total of 4.5 lb a.e. can be applied during this time frame. Hence, depending upon application rate, four to six applications can be made overtop or directed. An additional 1.55 lb a.e. can be applied from the 60-percent-open-boll stage until seven days prior to harvest. Regardless of label flexibility, growers should not overly rely on glyphosate; see the *Herbicide Resistance Management* section.

Tank Mixes with Glyphosate Applied Overtop

Acetochlor (Warrant) plus glyphosate can be applied after cotton is completely emerged but before first bloom. Warrant does not control emerged weeds but provides residual control of many grasses and small-seeded broadleaf weeds including tropical spiderwort. A second POST application of Warrant can be made if it was not applied PRE. Injury from POST applications is temporary when applications are made by the 8-leaf cotton stage; this application can cause minor stunting at times but no speckling on later-emerging leaves or adverse effect on yield or maturity is expected. The exception has been when additional adjuvants or insecticides are included in the mixture where severe injury is possible. Injury will also be greater if Warrant is applied when dew is on the cotton, when the weather is extremely hot and humid, and especially when soils are saturated.

Acetochlor (Warrant) **vs. S-metolachlor** (Dual Magnum). Although these herbicides are similar in many ways there are some distinct differences. Georgia research suggests Dual Magnum is much easier to activate and provides immediate Palmer amaranth control once activated while Warrant requires a few days after activation to become fully active. However, Warrant is far more effective after lying on the soil for 7 to 12 days to be activated. Also, Warrant can be applied PRE to cotton while Dual Magnum should not. Neither product should be applied preplant.

Dimethenamid (Outlook) can be applied overtop of cotton in a mixture with glyphosate from the first true leaf stage until second week of 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 and the herbicide is also similar to Dual Magnum becoming active very quickly after irrigation or rainfall.

Labeled grass herbicides (clethodim, fluazifop, quizalofop, and sethoxydim) can be mixed with glyphosate to control volunteer Roundup Ready corn and for improved control of goosegrass.

Pyrithiobac (Staple LX) can be mixed with Roundup and applied overtop of RR Flex cotton from the cotyledonary stage until 60 days prior to harvest. Staple rates in this mixture range from 1.3 to 3.8 oz/a (prefer 2.0 oz/a for residual control and 2.7 oz/a for postemergence control) and will improve control of hemp sesbania, morningglory (except tall morningglory), spreading dayflower, glyphosate-resistant Palmer amaranth (assuming it is not also ALS-resistant) and tropical spiderwort. Staple also will give residual control of susceptible weeds, such as pigweed species, spurred anoda, and velvetleaf. Palmer amaranth resistant to Staple and other ALS inhibitors are present across Georgia.

Roundup plus Staple may cause temporary yellowing of the cotton bud. Research has demonstrated that cotton recovers quickly, and there is seldom an adverse effect on yield or maturity. On occasion, however, Staple applied overtop can cause moderate to severe injury. The potential for significant injury appears to be greater when the herbicide is applied during or shortly before a period of cool temperatures. In addition to cool temperatures, other stresses such as wet weather, seedling disease, or thrips damage may worsen injury. Slower recovery from Staple injury has particularly been noted on cotton infested with Thrips.

***S*-metolachlor** (Dual Magnum, many generics) can be applied overtop of cotton until 100 days before harvest and directed until 80 days of harvest. Crop injury from a mixture of Roundup plus Dual Magnum overtop is typically minor, with only necrotic speckling noted on leaves exposed to the spray. Injury from POST applications is temporary when applications are made by the 8-leaf cotton stage; this application can cause minor stunting at times but no speckling on later-emerging leaves or adverse effect on yield or maturity is expected. The exception has been when additional adjuvants or insecticides are included in the mixture where severe injury is possible. Injury will also be greater if Dual Magnum is applied when dew is on the cotton, when the weather is extremely hot and humid, and when soils are saturated.

Mixing Dual Magnum with Roundup will not improve control of emerged weeds. However, if timely rainfall for activation is received, Dual Magnum can provide residual control of most annual grasses (only suppression of Texas panicum), pigweed species (including Palmer amaranth), tropical spiderwort, and doveweed with suppression of yellow nutsedge and spreading dayflower.

Both metolachlor and S-metolachlor are available. Growers should be aware that metolachlor is less effective than *S*-metolachlor. Metolachlor is a mixture of four stereoisomers. 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. Products whose labels designate *S*-metolachlor contain primarily the active isomers. Labels for products containing metolachlor specify the same rate of formulated product per acre as those containing *S*-metolachlor, hence growers are getting less of the active form of the herbicide when using metolachlor products. One would have to increase the rate of a metolachlor product by 50 percent to get the same activity as a product containing *S*-metolachlor.

A prepackaged mixture of the potassium salt of Roundup plus Dual Magnum (Sequence) is available. At 2.5 pt/a, this premix provides 0.7 lb a.e. of Roundup + 1 pt of Dual Magnum.

Trifloxysulfuron (Envoke) can be mixed with certain brands of Roundup and applied overtop of cotton from the five (prefer 7)-to-12-leaf stage and at least 60 days before harvest for improved nutsedge, morningglory, and smartweed control. Injury can occur, thus, growers sensitive to visual symptomology are encouraged to sloppy direct the application. The mixture applied topically is expected to cause some yellowing in the cotton terminal and shortening of internodes. Less response is typically observed on larger cotton.

Tank Mixes with Glyphosate Directed

In almost every case where Roundup is being directed, it is advisable to add a tank-mix partner to improve control of certain emerged weeds and/or to provide residual control. *Tank mixes are also recommended as part of a resistance management program.* Potential tank-mix partners with Roundup postemergence-directed include Aim, Caparol, diuron, Dual Magnum, Envoke, ET, Fierce, Outlook, Staple, Valor, Warrant, and Zidua.

Acetochlor (Warrant), **dimethenamid** (Outlook), **pyroxasulfone** (Zidua), or ***S*-metolachlor** (Dual Magnum, many others) mixed with Roundup will not improve control of emerged weeds. However, if reaching the soil and activated, they will provide residual control of many annual grasses, tropical spiderwort, and small-seeded broadleaf species, including Palmer amaranth. Warrant can be directed anytime up to first bloom of cotton. Zidua can be directed from the five-leaf stage to first bloom; make sure not to apply Zidua topically. Dual Magnum can be directed to cotton through 80 days before harvest and Outlook can be used in cotton through the 2nd week after initial bloom.

Carfentrazone (Aim) and **pyraflufen ethyl** (ET) will improve morningglory control when mixed with Roundup. Additionally, Aim will provide excellent control of tropical spiderwort less than 4 in. Cotton should be at least 20 in. 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.

Diuron (Direx, others) or prometryn (Caparol, others) mixed with Roundup will improve control of Palmer amaranth and many other broadleaf weeds; for larger morningglory one likely needs to also include Envoke in the mixture. Products containing Direx applied at 1.5 pt/a or products containing prometryn applied at 2 pt/a will provide some residual control of small-seeded broadleaf weeds, including pigweed, if an activating rainfall is received. Direx is generally more effective on pigweed than Caparol. Cotton should be at least 12 in. tall before directing these products at these rates. Occasionally, mixing these herbicides with Roundup will reduce grass control compared to Roundup alone or at least delay death of the grasses. This is most likely to occur when grasses are large and/or under harsh conditions. Use the maximum glyphosate rate labeled when applying these mixtures.

Flumioxazin (Valor SX, Valor EZ, others) mixed with Roundup will improve control of doveweed, Florida pusley, tropical spiderwort, and morningglory while also providing excellent residual control of many weeds including Palmer amaranth, pusley, and purslane. Cotton should be at least 18 in. tall with a completely "woody" stem before this combination is precisely directed to the bottom 1- to 2-in. of the cotton stem. Add nonionic surfactant at 1 qt per 100-gallon 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 has a very favorable rotational package.

Flumioxazin plus pyroxasulfone (Fierce) can be used in the same manner as Valor, discussed above. It will improve control of many emerged weeds while providing excellent residual control of grasses and many broadleaf weeds. Fierce will provide better residual control of grasses, tropical spiderwort, and some small-seeded broadleaf weeds when compared to Valor.

Pyrithiobac (Staple LX) mixed with Roundup will improve control of hemp sesbania, morningglory (except tall morningglory), spreading dayflower, tropical spiderwort and glyphosate-resistant Palmer amaranth. Staple can also provide residual control of susceptible species such as prickly sida, non-resistant pigweed species, spurge, velvetleaf, and spurred anoda.

Trifloxysulfuron (Envoke) mixed with Roundup will improve control of nutsedge and larger morningglory. Cotton should be at least 6 in. tall. Envoke has some residual activity on susceptible broadleaf weeds if activated.

Glyphosate Mixtures versus Other Directed Herbicides

On glyphosate-tolerant cotton, one has the option of directing either Roundup or a traditional herbicide combination such as Direx + MSMA. Better broadleaf weed control, especially Palmer amaranth, is sometimes obtained when traditional directed herbicides are used. If, however, grasses are a predominant problem, and they are larger than 1 in., Roundup mixtures are better options.

GLUFOSINATE (LIBERTY) ALONE OR IN MIXTURES FOR TOLERANT COTTON

Although most cultivars currently have tolerance to glufosinate, be certain to only apply glufosinate over-the-top of tolerant cultivars or crop injury will be severe.

Timing of Liberty (glufosinate) Application

The Liberty label currently allows three applications of 29 oz/a, for a seasonal total of 87 oz/a. Alternatively, one can apply 32 to 43 oz/a once, followed by one more application of 29 oz/a for a seasonal total not exceeding 72 oz/a. Liberty can be applied from cotton emergence until the early bloom stage. A Section 24(c) label allows two applications as close as 5 days apart when Liberty is applied alone with a maximum rate of 36 oz/a; if using tank mixtures, the interval between sequential applications is at least 10 days.

Application of Liberty should be based on weed size rather than crop size. The optimum weed size for treatment varies by weed species and growing conditions. In general, most broadleaf weeds should be no more than 4 in. tall. Pigweed species, including Palmer amaranth, and most annual grasses should be no more than 3 in. tall. Under dry conditions, weed size should be less than 2 in. Goosegrass and tropical spiderwort likely will not be adequately controlled. Optimum timing for the first application generally occurs 14 to 18 days after cotton emergence assuming an effective at-plant residual herbicide was used and activated, with optimum timing of the second application 14 to 18 days after the first application, assuming the first application is timely. For situations where the pigweed is too large to control with the first application, a second application should be made 5 to 7 days later following Georgia's 24(c) label requirements.

Protecting Liberty

Because of weed resistance coupled with the lack of new herbicide modes of action, Liberty (generics) will continue to play a significant role in cotton weed management. 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 two applications of Liberty (generics) per year.**
2. **Spray Liberty when the biggest pigweed in the field is 3 in. or smaller.**
3. **Never use a reduced rate!**
4. **Avoid applications within 1.5 hour of sunrise and 2 hours of sunset.**
5. **Apply at 15+ GPA using a speed, spray tip, and pressure that delivers a medium/course spray droplet.**
6. **Integrate herbicide programs with 1) cover crops, 2) tillage, and/or 3) hand weeding.**

Application Time of Day for Herbicides Impacts Weed Control

Activity of Liberty, Roundup, dicamba, 2,4-D, Reflex, and Diuron is influenced by the time of day in which they are applied. For Roundup, dicamba, and 2,4-D, applications near sunrise or sunset cause below average performance on Palmer amaranth. *Liberty is the most vulnerable and should not be applied within 1.5 hours of sunrise and 2 hours of sunset* (Figure 14).

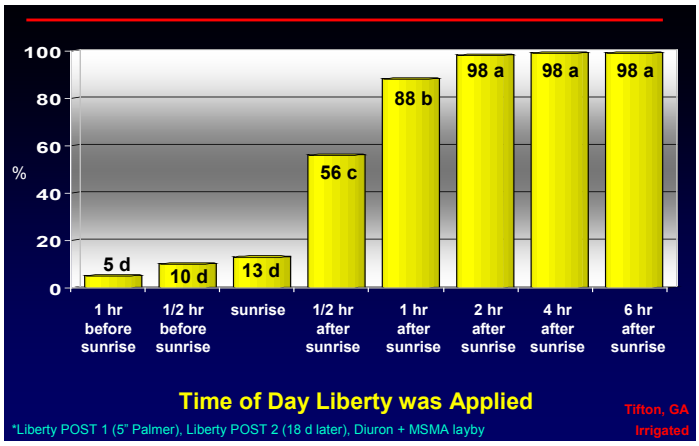


Figure 14. Irrigated Cotton Seed Yield vs. Glyphosate-Resistant Palmer Amaranth Density.

Application Equipment

Liberty behaves primarily as a contact herbicide, so good spray coverage is necessary. Ideally, the spray volume is at least 15 gal/a. Ultimately the goal with Liberty is to achieve thorough spray coverage thus growers must understand the relationship of speed, pressure, and nozzle type to achieve this goal. *"Dicamba" nozzles may not be satisfactory for Liberty applied alone.*

Tank Mixes with Liberty Applied Overtop

Acetochlor (Warrant), **dimethenamid** (Outlook)**, pyrithiobac** (Staple LX), and ***S*-metolachlor** (Dual Magnum, others) can be mixed with Liberty. Warrant can be applied after cotton is completely emerged but before first bloom and a second POST application can be made if Warrant was not applied PRE; Outlook can be applied from 1-leaf cotton through the second week of bloom; Dual Magnum can be applied overtop of fully emerged cotton until early bloom or 100 days before harvest (whichever is more restrictive). Staple can be applied overtop of cotton from full cotyledonary cotton through early bloom or 60 d before harvest (whichever is more restrictive).

Warrant, Outlook, and Dual Magnum do not improve control of emerged weeds but will provide residual control of many grasses, small seeded broadleaf weeds, and tropical spiderwort if activated. Staple mixed with Liberty may improve control of emerged pigweed and spiderwort while providing residual control of numerous broadleaf weeds including non-resistant pigweed (see weed response to herbicides in appendix).

In Liberty Link cotton, mixtures of Liberty plus Dual Magnum, Warrant or Staple will be similar to that noted with respective comparable Roundup mixtures. Injury is expected to be slightly higher in XtendFlex cotton.

Glufosinate + Glyphosate. In cotton tolerant to glyphosate and glufosinate, growers have the option of using both Roundup and Liberty, either sequentially or in a tank mix. This mixture has become common for the control of broadleaf and grass weeds infesting cotton. In general, the tank-mix will provide excellent control of broadleaf weeds that are sensitive to the herbicides. For grasses, the tank mixture is often less effective than glyphosate alone but more effective than glufosinate alone. Similarly, for wild radish, mixing glufosinate with glyphosate will greatly reduce control far beyond that of glyphosate alone. A tank-mix is not suggested for goosegrass or perennial grasses (e.g., bermudagrass or johnsongrass); instead, use sequential applications with Roundup applied 3 to 5 days prior to Liberty.

Glufosinate in a Directed Application

Liberty can be directed in cotton tolerant to glufosinate up to the early bloom stage and can be directed alone or mixed with herbicides such as Aim, Direx (others), Caparol (others), or Staple LX. Most Liberty-based systems will include two overtop applications of Liberty; thus, growers are encouraged to utilize conventional chemistry at layby for resistance management.

WEED MANAGEMENT IN XTENDFLEX COTTON

XtendFlex cotton has tolerance to glyphosate (Roundup, etc), glufosinate (Liberty, etc), and dicamba (Engenia, XtendiMax, Tavium). Herbicides discussed under *Glyphosate Alone and in Mixes for Tolerant Cotton* and *Glufosinate Alone and in Mixes for Tolerant Cotton* can be used in XtendFlex cotton.

Applicators must have a certified pesticide license and also have attended the Using Pesticides Wisely training for the current year before applying Engenia, XtendiMax, or Tavium in Georgia; no other dicamba formulation is labeled for applications in-crop. Use of labeled dicamba formulations will reduce, but not eliminate, the potential for volatility. *Additionally, postemergence applications of these herbicides must be supported by sound at-plant herbicide mixtures, a directed layby application, cover crops or tillage, and hand removal of all Palmer amaranth escapes.*

Only certain herbicides are allowed to be tank-mixed with *Engenia, XtendiMax or Tavium.* Permissible tank mixtures with Engenia or XtendiMax can be found online at www.engeniatankmix.com or www.xtendimaxapplicationrequirements.com and those for Tavium can be found at www.TaviumApplicationRequirements.com.

Application Timing

Engenia and XtendiMax can be used for *burndown/early preplant, preplant, at-planting, or preemergence*; a maximum of two applications at 0.5 lb ai/a (XtendiMax 22 oz/a; Engenia 12.8 oz/a) is approved. *Two additional*

postemergence applications can be made in-crop, again each with a maximum rate of 0.5 lb ai/a. Current labels require applications to be completed by July 30. Dicamba should almost always be mixed with a labeled glyphosate formulation. Sequential applications of dicamba must be separated by at least 7 days. Applications should be timely; broadleaf weeds should be less than 4 in. tall with Palmer amaranth needing to be less than 3 in. To avoid the potential for significant visual damage, applications after cotton reaches the 8-leaf stage of growth should be directed.

Applied as part of the *preplant burndown program*, dicamba can help control weeds such as glyphosate-resistant horseweed and cutleaf eveningprimrose (see *Burndown* discussion). Engenia or XtendiMax can be mixed with selected brands of glyphosate, Valor and diuron when applied preplant. Although the plant back interval is removed for dicamba in dicamba-tolerant cotton, the standard plant back interval for Valor and diuron still apply.

Preemergence application of dicamba is generally discouraged. Although dicamba can give good residual control of some broadleaf weeds if the weather cooperates, the control is often short-lived (10 days or less), and it is quite inconsistent. Preemergence application of dicamba should be considered only in situations where crop injury is a serious concern with all other residual herbicides and where paraquat is not a good burndown option. An example might be large horseweed not adequately controlled by an earlier burndown.

Postemergence tank mixtures for Engenia or XtendiMax include selected brands of glyphosate, selected brands of clethodim, Dual Magnum, Staple, or Warrant. Engenia can also be mixed with Outlook. Tavium is a premix of XtendiMax and Dual Magnum and may be applied over tolerant cotton through the 6-leaf stage or July 30, whichever comes first. *There is significant uncertainty with the dicamba technology regarding regulatory actions; thus, contact your local extension agent to determine if these application restrictions have changed.*

Drift reduction adjuvants (DRAs)

DRAs are required for many in-crop dicamba applications as influenced by tank-mix partner, websites above provide requirements and approved DRA products.

Volatility Reduction Agents (VRAs), pH Buffering Adjuvant

These products are required when applying labeled herbicides in dicamba-tolerant cotton to reduce volatility; use only products approved on the manufacturers website at recommended rates. These products potentially buffer against significant changes in solution pH and prevent the formation of dicamba acid by scavenging extraneous protons. The photograph on the right shows the potentially enormous benefit that these products can have in some environments.

WEED MANAGEMENT IN ENLIST COTTON

Certain Phytogen varieties, designated as W3FE, carry the Enlist trait and are tolerant of 2,4-D (Enlist One, Enlist Duo), glyphosate (Roundup, etc), and glufosinate (Liberty, etc). In contrast to WRF varieties, varieties designated as W3FE have essentially complete tolerance of glufosinate. Any of the programs discussed above under *Glyphosate Alone and in Mixes for Tolerant Cotton* and *Glufosinate Alone and in Mixes for Tolerant Cotton* can be used in Enlist cotton. Additionally, Enlist One (contains the choline salt of 2,4-D) and Enlist Duo (contains glyphosate plus the choline salt of 2,4-D) can be applied with the exception that Enlist Duo is not currently labeled for use in eleven Georgia counties including Baker, Berrien, Brooks, Burke, Calhoun, Early, Irwin, Lee, Miller, Screven, and Worth. These are the only brands containing 2,4-D that can be applied to Enlist cotton. Use of these brands will reduce, but not eliminate, the potential for volatility. *Additionally, postemergence applications of Enlist One or Enlist Duo must be supported by sound at-plant herbicide mixtures, a directed layby, cover crops or tillage, and hand removal of all Palmer amaranth escapes.*

Permissible tank mixtures with Enlist One or Enlist Duo can be found online at www.enlisttankmix.com. Drift reduction agents are not required with Enlist One tank mixes, although certain ones are approved for application.

Application Timing

Enlist One and Enlist Duo can be applied *any time prior to planting, preemergence after planting, and postemergence in fields growing Enlist Cotton*. An advantage of Enlist cotton is that there is no waiting period between *preplant application* and planting. However, a timely burndown application at least 14 days ahead of planting is still encouraged for fields infested with weeds or broadleaf cover crops. Valor and/or diuron are critical components to a burndown program and each can be used with Enlist herbicides, see website for specially approved brands. Although the plant back interval is removed for 2,4-D choline in Enlist cotton, the standard plant back interval for Valor and diuron still apply.

A good *preemergence* herbicide program is absolutely essential in Enlist cotton regardless of the postemergence program; however, 2,4-D choline should be considered as a preemergence application only in situations where burndown herbicides did not effectively control weeds prior to planting. Far better residual herbicides are available for use at planting.

Enlist One or Enlist Duo can be applied *postemergence* any time from cotton emergence until the mid-bloom stage. Apply postemergence no more than twice per season. Separate applications by at least 12 days. Applications should be timely; broadleaf weeds should be less than 4 in. tall with Palmer amaranth needing to be less than 3 in. To avoid the potential for significant visual damage and improved weed control, applications after cotton reaches the 8-leaf stage of growth should be directed. Enlist One can be applied postemergence in mixture with specific brands of glyphosate, specific brands of glufosinate including Liberty, Dual Magnum, and Warrant.

POSTEMERGENCE HERBICIDES APPLIED OVERTOP FOR ANY COTTON VARIETY

Pyrithiobac (Staple LX) can be applied overtop of cotton from the cotyledonary stage until 60 days before harvest. Two applications per year are allowed as long as the total applied per season does not exceed 5.1 fl oz. If applied in a timely manner, Staple controls many broadleaf weeds (see weed response charts in appendix) but does not adequately control lambsquarters, ragweed, sicklepod, spurge, tall morningglory, or tropic croton. Most susceptible broadleaf weeds should not be taller than 3 in.; prickly sida and Palmer amaranth must be 1 in. or less. Palmer amaranth resistant to Staple and other ALS-herbicides is present in Georgia.

Mixing Staple with grass herbicides such as Select, Fusilade, Assure II, and Poast is not recommended because reduced grass control (antagonism) is often observed. When making sequential applications of Staple and a postemergence grass-control herbicide, apply Staple at least five days before or three days after application of the grass-control herbicide.

Trifloxysulfuron (Envoke) can be applied overtop of cotton with a minimum of five (prefer 7) leaves up to 60 days prior to harvest. Injury from topical applications is a concern; thus, directed applications are strongly encouraged. In cotton after the 8-leaf stage, directed or semi-directed application may improve spray coverage on weeds below the crop canopy as well. For best control, weeds should be less than 3 in. tall. Envoke controls or suppresses nutsedge plus a number of broadleaf weeds (see weed response charts in appendix) but does not control jimsonweed, prickly sida, spreading dayflower, or spurred anoda, and it is not adequately effective on tropic croton. Control of Palmer amaranth is usually inadequate.

Staple and Envoke have the same mechanism of action; thus, ALS-resistant Palmer amaranth will not be controlled by either product.

Injury from Envoke applied topically is expressed as yellowing in the growing point and shortened internodes. Some degree of crop response can almost always be expected. In most cases, the injury is relatively minor and the crop recovers. On occasion, however, moderate to severe injury has been observed. Smaller cotton appears to be injured more than larger cotton. Growers are encouraged to not apply the herbicide to cotton under stress from wet or dry weather or thrips. Also, carefully follow label directions for adjuvant usage and tank mixtures. Tank mixes of Envoke with grass control herbicides (such as Select, Poast, etc) should be avoided. Separate applications of Envoke and the grass-control herbicides by at least 3 days if the grass-control herbicide is applied first or 5 days if Envoke is applied first.

Grass-control herbicides. Clethodim (Select, others), fluazifop (Fusilade, others), quizalofop (Assure II, others), and sethoxydim (Poast, others) can be applied overtop of cotton from emergence through midseason. These products control annual and perennial grasses but are ineffective on nutsedge and broadleaf weeds. All of these products are safe on cotton and are effective when applied to small grasses under good growing conditions. However, Select and Poast tend to be more effective over a range of annual grass species and environmental conditions. Select, Fusilade and Assure II tend to be more effective on perennial grasses than Poast. When using any of these herbicides, follow label directions for application rates, application methods, use of adjuvants, and optimum grass size for treatment. Tank-mixing broadleaf herbicides such as Staple or Envoke with these postemergence grass-control herbicides is not recommended.

POSTEMERGENCE-DIRECTED HERBICIDES FOR ANY COTTON VARIETY

Several herbicide combinations are available for directed application to any variety of cotton. More common options include Caparol + MSMA, Cotoran + MSMA, diuron + MSMA, Fierce + MSMA, and Valor + MSMA. Aim, Dual Magnum, Envoke, ET, Outlook, Staple, Warrant, and Zidua may be added to some (not all) of these combinations; follow the most restrictive requirements for products in tank mixtures for application timings, cotton stage of growth, etc.

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

Diuron + MSMA has many strengths and is the most commonly used of these options. The mixture only has two weed control weaknesses. *First,* it lacks control of larger (> 4 in.) morningglory. When both Palmer amaranth and morningglory need to be controlled then one should consider including Envoke with the diuron + MSMA; Envoke will also improve nutsedge control. *Second,* diuron + MSMA lacks control of grasses larger than 1 in. If Palmer amaranth is not problematic but grasses larger than 0.5 in. are an issue, Roundup mixtures in tolerant cotton will be more effective.

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 when the cotton is packed into a bale or module.

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 are usually not acceptable. These products will not desiccate grasses or sicklepod. See labels and the defoliation section regarding adjuvants and the potential for causing issues such as sticking cotton leaves.

Roundup can be applied after 60% of the bolls are open in non-tolerant cotton and can be applied to tolerant cotton until 7 days before harvest.

Paraquat. Either add 2 to 6 fl oz of product with standard defoliants or apply after cotton defoliation; confirm this use is on the label of the paraquat brand used. When applying after cotton defoliation and at least 85 percent of the bolls are open, the remaining bolls expected to be harvested are mature, and most of the cotton leaves have dropped, apply 11 to 21 oz/a of Gramoxone 3 SL; see label for rates of other brands. Broadcast 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; label suggests waiting 3–7 days and then pick as soon as possible. Paraquat will desiccate most annual weeds with Florida pusley being an exception; desiccation of wild radish is often not ideal as well unless it is fully mature. Cotton must be harvested in a timely manner, bark and cotton plant death can occur rapidly. Although rare, cotton lint may turn a light purple color soon after application.

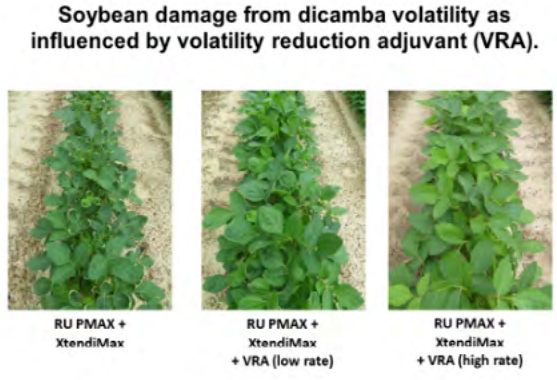


Figure 15. Soybean Damage From Dicamba Volatility as Influenced by Volatililty Reduction Adjuvant (VRA).

Perennial Weeds

Glyphosate (Roundup) can be applied in the fall to control or suppress perennial weeds for the following year. For weeds that will receive adequate coverage with the defoliation application, glyphosate at a rate of 0.75 to 1.5 lb a.e./a may be tank-mixed with the defoliant, depending on weeds present. Apply when at least 60 percent of the bolls are open. Alternatively, glyphosate may be applied after defoliation which may be preferred in rank cotton to improve spray coverage. Additionally, a separate application of glyphosate allows treatment of only the infested areas.

For perennial weeds, such as bermudagrass, nutsedge, trumpetcreeper, horsenettle, common milkweed, and hemp dogbane, glyphosate-defoliant tank mixes may not provide adequate coverage and a follow-up spot application may be needed. Suggested application rates are 1.5 lb ae/a for johnsongrass, 2.25 lb ae/a for nutsedge, trumpetcreeper, common milkweed, and bermudagrass, and 3 lb ae/a for horsenettle and hemp dogbane. To reduce costs, spot-spray only infested areas.

Glyphosate should be applied at least 7 days before the first killing frost for all weeds.

MANAGING THE MOST TROUBLESOME WEEDS IN THE COTTON CROP

Bermudagrass: For success, fall applications are needed. At least 7 days before frost, apply Roundup at 2.25 lb a.e./a in single application or two applications 7 days apart at 1.13 lb ae/a. During the following season implement both Roundup and postemergenence graminicides when feasible. Postemergence graminicides (Select, Select Max, Fusilade DX, Assure II) are effective options when bermudagrass has runners less than 6 in.; however, a tank mix of Roundup plus a graminicide would likely be the most effective option when labeled.

Doveweed: Roundup will only provide suppression while Liberty has even less activity. Dual Magnum and Warrant will control doveweed if activated before germination. Paraquat preplant or through hooded sprayers will control emerged doveweed. And, directed applications of Valor plus MSMA, Valor plus Roundup, and diuron plus Roundup are fairly effective on emerged plants.

Florida pusley: The key for control begins with applying residuals prior to emergence. Treflan, Prowl, Cotoran, diuron, Valor, and Warrant control this weed if applied properly and activated. Additionally, one should include residual herbicides with POST and layby applications to prevent the weed from continually emerging. Florida pusley can be controlled by Roundup but ONLY if applied at the full rate when the weed is very small (1 in. or less) and under ideal conditions; multiple applications are often necessary. Roundup is more effective than Liberty. Dicamba or 2,4-D in mixture with Roundup will improve control.

Glyphosate-resistant common ragweed: Common ragweed resistant to Roundup is present in North Carolina. Common ragweed emerges earlier than many other summer annual broadleaf weeds. Valor applied early burndown in combination with Roundup plus 2,4-D or dicamba will provide residual control of early emerging common ragweed. Brake plus Reflex, Cotoran, or Reflex plus diuron applied preemergence are effective. Common ragweed can be controlled postemergence with Liberty while Envoke also provides activity. Most of the conventional directed herbicide combinations as well as dicamba and 2,4-D are also effective.

Glyphosate-resistant Palmer Amaranth: Palmer amaranth is Georgia's most problematic weedy pest. It is imperative that growers continue to use sound herbicide programs but also integrate these programs with other control measures, such as 1) hand-weeding, to remove escapes before seed are produced, 2) deep turning to reduce the number of plants emerging (ideally wait 3.5 to 5 years or more before repeating), and/or 3) using a cover crop mulch 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 PPO (Reflex, Valor) inhibitors, Liberty and dicamba. Because these herbicides are critical to control glyphosate-resistant Palmer amaranth in cotton, it is a grower's best interest to prevent or at least slow further selection for resistance to these herbicides.

Suggested herbicide programs are available on circulars at www.gaweed.com or at the local Extension office. For conventional tillage systems, Treflan or Prowl are effective on Palmer amaranth if shallowly and uniformly incorporated. Additionally, Georgia has a label allowing Reflex to be split-applied with 8–12 oz/a of Reflex mixed with Treflan or Prowl and shallowly incorporated in the soil followed with a preemergence application of Reflex at 8–10 oz/a plus an additional residual herbicide.

In strip-till systems, an early preplant burndown application of Roundup plus either 2,4-D or dicamba is suggested for good burndown of a wide range of species, including glyphosate-resistant horseweed, wild radish, and cutleaf eveningprimrose. Valor should be included in this burndown application providing excellent residual Palmer amaranth control. This can be very important if timely rainfall is not received following planting to activate the preemergence herbicides. If Palmer amaranth is already emerged and greater than 1 in. in height at time of burndown, the addition of diuron will be beneficial in controlling emerged plants. If Palmer amaranth is present just prior to planting then the most effective option is paraquat + Direx plus Crop Oil. Make sure to control the weed prior to planting. *Follow appropriate herbicide plantback intervals.*

Regardless of the tillage system, a strong preemergence program is needed. Apply one of the preemergence options noted in Table 4 (*selecting PRE herbicide section*) within 24 hours of planting and include paraquat plus adjuvant with the at-plant herbicide if weeds are emerged.

For most fields, two timely postemergence applications will be needed regardless of cotton technology planted. Many growers are trying to avoid layby applications, but research has clearly shown these applications are critical to achieve the goal of mitigating additional Palmer amaranth seed being added to the soil seedbank, which is critical for overall farm sustainability.

Goosegrass: All fields must begin free of this pest at planting and should include a residual at-plant herbicide such as Warrant or Prowl. Roundup is an effective option but only if the weed is small, the full glyphosate rate is applied, and conditions are favorable. The addition of residual herbicides such as Dual Mangum, Outlook, or Warrant should be included with Roundup. Liberty is not an effective option for goosegrass. Mixing Roundup and Liberty will reduce the activity of Roundup on goosegrass; thus, for goosegrass apply Roundup without Liberty. POST grass herbicides can also be effective but must be applied very timely; these products can be mixed with Roundup but mixtures with Liberty are quite antagonistic. Goosegrass resistant to Roundup and POST grass herbicides are present in nearby states.

Hemp sesbania: Currently no data exists for the weed's response to Liberty. For Roundup, hemp sesbania is very difficult to control after the first true leaf. Data from other states show Roundup + 2,4-D or dicamba mixtures should provide very good control. When auxins cannot be used and the weed 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 including Cobra or Envoke. Envoke overtop of cotton would also be an option but since cotton must be at least 5-leaf (prefer 7) before application, sesbania may be greater than 3 in. at time of treatment which would likely end up providing poor control.

Morningglory: Cotoran preemergence is useful in heavily infested fields. Liberty, 2,4-D or dicamba provide outstanding control of emerged plants as long as the appropriate rate, weed size, and weed coverage are

achieved. Staple is also very effective controlling emerged morningglory (except for tall morningglory) as well as suppressing newly emerging plants. For Roundup, a single application rarely provides control thus a tank mix partner is likely beneficial. Envoke also controls *Ipomoea* morningglory very well.

At time of layby, conventional chemistries mixed with MSMA or Roundup such as Caparol, Cobra, diuron, Envoke, Staple, or Valor would be effective if used appropriately. Diuron plus MSMA or Roundup + diuron have become standard layby treatments; however, the addition of Envoke with these mixtures is encouraged for improved morningglory control. See labels for application timings and cotton sizes. For fields where morningglory emerge late in the season, including Staple and Cotoran with the layby would offer the most effective residual activity.

Nutsedge: Few herbicides are effective on nutsedge and a systems approach is almost always required. The most effective system will include sequential applications of Roundup applied topically with applications 7 to 10 days apart just to hold the nutsedge in place followed by a layby mixture of glyphosate or MSMA plus Envoke (0.15 oz/a) plus diuron or Caparol; it is the layby application that ultimately controls most of the population. Although Liberty and Gramoxone provide a visual perception of control, they usually are not an effective option.

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. New Enlist and XtendFlex technologies allowing sequential applications of dicamba or 2,4-D mixed with Roundup will prove beneficial in the control of these perennial broadleaf weeds.

For fields where auxin herbicides cannot be used, control will be difficult. Horsenettle can be controlled with postemergence-directed herbicide combinations containing MSMA. Perennial broadleaf weeds can be suppressed or controlled with multiple applications of Roundup. Applications later in the season 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. Additionally, glyphosate + dicamba mixtures can be quite effective.

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.

Roundup Ready soybean (volunteer): At planting, Cotoran is the most effective option to suppress emergence and growth of soybean. For emerged plants, Liberty will effectively control non-Liberty tolerant soybean while Envoke will suppress or potentially control non-ALS tolerant soybean; soybeans must be small for both herbicides to provide complete control. Similarly, dicamba applied to non-tolerant volunteers will be extremely effective. Staple postemergence typically does not control soybean; however, Staple applied to three- to four-trifoliate non-ALS tolerant soybean followed by a directed application of Caparol or diuron plus MSMA as well as any Envoke mixture may provide adequate control.

Tropical spiderwort: Dual Magnum, Outlook, Zidua, and Warrant offer the greatest level of residual control in cotton; *well-placed residual herbicides are the key to a successful spiderwort management program*. Paraquat, Roundup + Aim, Roundup + 2,4-D, Roundup + dicamba (two applications that must begin with 3 in. or smaller spiderwort), Roundup + Staple, and Direx + MSMA offer the greatest opportunity to control emerged plants. The addition of residual herbicides in conjunction with these POST treatments will be needed. Liberty is not effective; Roundup actually provides better control than Liberty.

COTTON WEED CONTROL

A. Stanley Culpepper, Extension Agronomist – Weed Science

WEED	HERBICIDE	MOA	BROADCAST RATE/aCRE		REI/PHI (Hours or Days)	REMARKS AND PRECAUTIONS
			AMOUNT OF FORMULATION	LBS ACTIVE (AI or AE)		
PRE-PLANT BURNDOWN – ANY VARIETY						
Emerged primrose, wild radish, spiderwort, small horseweed. Data suggests the choline formulation of *2,4-D* has reduced volatility potential when compared to other *2,4-D* formulations.	*2,4-D amine* 3.8 S 5.5 S	4	 12-32 fl oz 9-22 fl oz	0.36-0.95	48 H/ N/a	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 cotton. **Amine formulations are less volatile than esters or acids.** PRIMROSE: apply 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
	2,4-D choline Enlist One 3.8 S	4	 24-32 fl oz	0.7-0.95	48 H/ N/a	Apply at least 30 days ahead of planting any variety not containing the Enlist trait. *See section below for cotton with the Enlist trait.* ***Be certain to study the label regarding requirements for training, buffers, wind speeds, ground speeds, spray tip requirements, and boom heights.*** **Users also must review website www.enlisttankmix.com for approved adjuvants, drift reduction agents, and tank mixtures.**
Burndown of mature primrose and morningglory. Inadequate control of immature radish, pigweeds over 3" or grain cover crops. *Mixtures with glyphosate are often very effective; however, research has shown Liberty to reduce glyphosate activity on large grasses and wild radish.*	*glufosinate* Liberty 2.34S	10	 29-43 fl oz	0.53-0.79	12 H/ N/a	Cotton may be planted anytime after application. **To maximize control:** > 15 GPA water volume, thorough spray coverage, warm temperatures, high humidity, bright sunlight, good soil moisture, and do not spray within 1.5 hours of sunrise or 2 hours 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.
Burndown of emerged annual weeds, but does not adequately control primrose, geranium, large radish, field pansy, resistant horseweed, or resistant Palmer amaranth. Morningglory, nutsedge, and purslane can be challenging. *For ryegrass, spray glyphosate and follow with paraquat 5 to 7 days later.*	*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) 5.88 S (4.8 lb ae) 6 S (5 lb ae)	9	 32-96 fl oz 24-72 fl oz 23-68 fl oz 22-64 fl oz 21-60 fl oz 19-58 fl oz	0.75-2.25 (lb ae)	4 H/ N/a	Apply anytime prior to planting. Sequential applications can be made not to exceed 3.7 lb ae/a for burndown. General rate for annual weeds is up to 1.13 lb ae (30 oz/a PowerMax 3), rate for nutsedge and some perennials is up to 2.25 lb ae (60 oz/a PowerMax 3). Cool nights just before and/or after application will delay and occasionally reduce weed control, especially for a wheat cover crop. *Control of cover crops:* Wheat < 12": 0.75 lb/a; Wheat > 12": 1.13 lb/a Rye < 12": 0.56 lb/a; Rye > 12" (no seed head): 0.75 lb/a; Rye > 12" (seed head): 0.56 lb/a

WEED	HERBICIDE	MOA	BROADCAST RATE/aCRE		REI/PHI (Hours or Days)	REMARKS AND PRECAUTIONS
			AMOUNT OF FORMULATION	LBS ACTIVE (AI or AE)		
PRE-PLANT BURNDOWN – ANY VARIETY *(continued)*						
Burndown of most emerged weeds. *2,4-D* is more effective than *dicamba* on primrose, radish, and spiderwort; less effective on horseweed and peanut. Data suggests the choline formulation of *2,4-D* has reduced volatility potential when compared to other *2,4-D* formulations.	*glyphosate* + *2,4-D choline* Enlist Duo 3.3 S	9 + 4	3.5-4.75 pt	0.74-1.0 (lb ae) + 0.7-0.95	48 H/ N/a	Apply at least 30 days ahead of planting non-Enlist traited cultivars. *See section below for cotton with the Enlist trait.* ***Be certain to study the label regarding requirements for training, buffers, wind speeds, tractor speeds, spray tip requirements, and boom heights.*** Users also must review website www.enlisttankmix.com for approved adjuvants, drift reduction agents, and tank mixtures. ***Enlist Duo is no longer labeled in 11 GA counties, make certain it is labeled in your county prior to use.***
Alternatively, Enlist One can be used in mixture with approved *glyphosate* formulations.	*glyphosate* + *2,4-D amine* 3.8 S 5.5 S	9 + 4	see *glyphosate* + 12-32 fl oz 9-22 fl oz	0.75-2.25 (lb ae) + 0.36-0.95	48 H/ N/a	Most, but not all, brands of *2,4-D* may be applied at least 30 days ahead of planting. For primrose, *2,4-D* at 0.38 lb ae/a will provide control. For *glyphosate*-resistant horseweed, 0.95 lb ae/a will control small plants. Lower rate of glyphosate for annual weeds and higher rates for perennial weeds, see label. **Amine fomulations are less volatile than amines or acids.**
Aim improves control of emerged morningglory, tropical spiderwort, and very small (< 1") *glyphosate*-resistant Palmer amaranth.	*glyphosate* + *carfentrazone* Aim 2 EC	9 + 14	see *glyphosate* + 0.5-1 fl oz	0.75-2.25 (lb ae) + 0.008-0.016	12 H/ N/a	May be applied as a burndown treatment anytime prior to planting. Lower rate of glyphosate for annual weeds and higher rates for perennial weeds, see label. Aim does not provide residual weed control.
Burndown of many weeds with dicamba at 0.5 lb ai/a; suppresses geranium and curly dock. Not overly effective at lower rates on most weeds. 2,4-D is more effective on primrose, radish, and spiderwort; *dicamba* 0.5 lb is more effective on horseweed and peanut.	*glyphosate* + *dicamba* Clarity, other 4S	9 + 4	see *glyphosate* + 8 fl oz	0.75-2.25 (lb ae) + 0.25	24 H/ N/a	**Comments are for non-XtendFlex; see section below for XtendFlex cotton!** *Dicamba* can be applied alone with little effect on the level of small grain biomass produced. Lower rate of glyphosate for annual weeds and higher rates for perennial weeds, see label. ***For Clarity:*** after a minimum of 1" of rainfall, a waiting period of at least 21 days is required before planting. **DO NOT INCLUDE AMS IN THIS MIX.** **Engenia and Xtendimax are only labeled for dicamba-tolerant cotton. The rotational interval for non-tolerant cotton follows:** **Following application of Engenia** and 1" of rain and a waiting period of at least 21, 28, or 42 days is required for rates of 6.4, 9.6, or 12.8 oz, respectively. **For Xtendimax** wait a minimum of 30 days for 22 oz/a according to the label with the addition of 1 in. of rainfall advised.

WEED	HERBICIDE	MOA	BROADCAST RATE/aCRE		REI/PHI (Hours or Days)	REMARKS AND PRECAUTIONS
			AMOUNT OF FORMULATION	LBS ACTIVE (AI or AE)		
PRE-PLANT BURNDOWN – ANY VARIETY *(continued)*						
Diuron improves control of emerged Palmer amaranth and offers residual control if activated on the soil. The addition of *2,4-D* or Valor will likely improve weed control; follow most restrictive plant-back interval.	*glyphosate* + *diuron* Direx 4L	9 + 7	see *glyphosate* + 1-1.5 pt	0.75-2.25 (lb ae) + 0.5-0.75	12 H/ N/a	**A Section 24(c) Georgia Special Local Need Label** allows Direx to be applied without a plant back interval as long as a strip-till rig with a ripper shank is run after application and before planting. If Direx is applied and a strip-till implement is not run then the plant back interval is 7 days. Other labeled diuron formulations require application 15-45 days ahead of planting. Label prohibits use on soils with less than 1% organic matter. Suggest not to apply another application of *diuron* or Cotoran within 21 days.
Valor improves emerged primrose and radish control; also provides residual control of pigweed, pusley, and other sensitive weeds for up to 6-8 weeks if activated on soil. The addition of *2,4-D* (8-16 oz/a of 3.8 lb ai material) improves 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. **DO NOT APPLY OVER 2 OZ/a OF VALOR FOR COTTON BURNDOWN WITHIN 60 DAYS OF PLANTING!**	*glyphosate* + *flumioxazin* Valor SX 51 WDG Valor EZ 4 SC	9 + 14	see *glyphosate* + 2 oz 2 fl oz	0.75-2.25 (lb ae) + 0.063	12 H/ N/a	**A Section 24c Georgia Special Local Need Label** allows reduced plant-back intervals for Valor. Outflank, Panther, and Rowel have been tested and perform similarly to Valor but do not have the following use patterns: **In strip-till cotton** where the strip till rig (including ripper shank) is run after application and before planting, Valor plant-back intervals are as follows: 1)> 30% ground cover = 7 days 2)10-30% ground cover = 14 days plus 0.5" rain/irrigation 3)<10% ground cover or tillage = 21 days plus 1" rain/irrigation **In no-tillage production** or when the strip is implemented prior to application. Valor plant-back interval should be a minimum of 28 days AND 0.5" (>10% ground cover) or 1" (<10% ground cover) rainfall/irrigation is required. *If Reflex (or generic) will be applied PRE, suggest adding an additional 7 days to planting intervals.* Add a nonionic surfactant or crop oil concentrate (preferred), regardless of *glyphosate* brand. Carefully follow label directions for cleaning sprayer after each use. Lower rate of glyphosate for annual weeds and higher rates for perennial weeds, see label.
ET improves control of emerged morningglory and small (< 1") *glyphosate*-resistant Palmer amaranth.	*glyphosate* + *pyraflufen ethyl* ET 0.208 EC	9 + 14	see *glyphosate* + 0.5-2 fl oz	0.75-2.25 (lb ae) + 0.0008-0.003	12 H/ N/a	May be applied as a burndown treatment anytime prior to planting. Lower rate of glyphosate for annual weeds and higher rates for perennial weeds, see label. ET does not provide residual weed control.

WEED	HERBICIDE	MOA	BROADCAST RATE/aCRE		REI/PHI (Hours or Days)	REMARKS AND PRECAUTIONS
			AMOUNT OF FORMULATION	LBS ACTIVE (AI or AE)		
PRE-PLANT BURNDOWN – ANY VARIETY *(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. FirstShot does not provide consistently effective residual Palmer amaranth control.	*glyphosate* + *thifensulfuron* + *tribenuron* FirstShot SG 50 SG	9 + 2+2	see *glyphosate* + 0.5-0.8 oz	0.75-2.25 (lb ae) + 0.008-0.013 + 0.008-0.013	12 H/ N/a	Apply at least 14 days prior to planting except for on sands and loamy sands where the interval should be at least 21 days. Include nonionic surfactant at 1 qt/100 gal spray or crop oil concentrate at 1 gal/100 gal spray. Lower rate of glyphosate for annual weeds and higher rates for perennial weeds, see label.
	glyphosate + *thifensulfuron* + *tribenuron* Harmony Extra SG with TotalSol 50 SG or Harmony Extra, Nimble 75WDG	9 + 2 + 2	see *glyphosate* + 0.75 oz 0.5 oz	0.75-2.25 (lb ae) + 0.0156 + 0.0075	12 H/ N/a	
Improved control of wild radish, morningglory, and small Palmer amaranth compared to *glyphosate* alone.	*glyphosate* + *tiafenacil* Reviton 2.83 SC	9 + 14	see glyphosate + 1-2 fl oz	0.75–2.25 (lb ae) + 0.022-0.044	12 H/ N/a	Cotton can be planted in 7 days following 1 oz/a of Reviton and 14 days following 2 oz/a. Lower rate of glyphosate for annual weeds and higher rates for perennial weeds, see label. Reviton can only be applied one time as a preplant burndown and the addition of MSO or crop oil may improve control on some weeds, see label.
Burndown of emerged annual weeds 3" or less. Does not control immature primrose, large horseweed, curly dock, swinecress, immature radish, or large grasses. *For ryegrass, glyphosate followed by paraquat* 5-7 days later is the best approach.	*paraquat* 2 SL 3 SL	22	 2.5-4 pt 1.7-2.7 pt	0.63-1	24 H/ N/a	**EPA has restricted the use of *paraquat* to certified applicators ONLY and applicators must take a specialized training before use.** Apply anytime prior to planting. Add nonionic surfactant at 2 pt/100 gal or crop oil concentrate at 1 gal/100 gal of spray mix. 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. **Mixtures with *diuron* are usually far more effective**.
Burndown of emerged annual weeds and provides residual control if *diuron* is activated on soil. Effective on mature primrose and wild radish. **BY FAR the most effective option for emerged pigweed.** If extended residual control is desired, consider adding Valor to the mixture but follow appropriate plant- back interval.	*paraquat* 2 SL 3 SL + *diuron* Direx 4F	22 + 7	 2.5-4 pt 1.7-2.7 pt + 1.5-2 pt	0.63-1 + 0.75-1	24 H/ N/a	**EPA has restricted the use of *paraquat* to certified applicators ONLY and applicators must take a specialized training before use.** **A Section 24(c) Georgia Local Need Label** allows Direx to be applied without a plant back interval as long as a strip-till rig with a ripper shank is run after application and before planting. If Direx is applied and a strip-till implement is not run then the plant back interval is 7 days. Other labeled *diuron* formulations require application 15-45 days ahead of planting. Label prohibits use on soils with less than 1% organic matter. Suggest not applying another application of *diuron* or Cotoran within 21 days. Add crop oil concentrate at 1 gal/100 gal spray mix. Applications to mature weeds are much more effective than to immature weeds.

WEED	HERBICIDE	MOA	BROADCAST RATE/aCRE		REI/PHI (Hours or Days)	REMARKS AND PRECAUTIONS
			AMOUNT OF FORMULATION	LBS ACTIVE (AI or AE)		
PRE-PLANT BURNDOWN – ANY VARIETY *(continued)*						
Paraquat mixtures with *diuron* are more effective on emerged Palmer amaranth; however, Valor is more effective in providing residual pigweed 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. **DO NOT APPLY OVER 2 OZ/a OF VALOR FOR COTTON BURNDOWN WITHIN 60 DAYS OF PLANTING!**	*paraquat* 2 SL 3 SL + *flumioxazin* Valor SX 51 WDG Valor EZ 4 SC	22 + 14	2.5-4 pt 1.7-2.7 pt + 2 oz 2 fl oz	0.63-1 + 0.063	12 H/ N/a	**EPA has restricted the use of paraquat to certified applicators ONLY and applicators must take a specialized training before use.** **A Section 24c Georgia Special Local Need Label** allows reduced plant-back intervals for Valor. Outflank, Panther, and Rowel have been tested and perform similarly to Valor but do not have the following use patterns: **In strip-till cotton** where the strip rig (including ripper shank) is run after application and before planting, Valor plant back intervals are as follows: 1)> 30% ground cover = 7 days 2)10-30% ground cover = 14 days plus 0.5 in. rain/irrigation 3)<10% ground cover or tillage = 21 days plus 1" rain/irrigation **In no-tillage production** or when the strip is implemented prior to application. Valor plant-back interval should be a minimum of 28 days AND 0.5" (>10% ground cover) or 1" (<10% ground cover) rainfall/irrigation is required. *If Reflex (or generic) will be applied PRE; data suggests an additional 7 days to planting intervals.* Add a nonionic surfactant or crop oil concentrate (preferred). Carefully follow label directions for cleaning sprayer after each use.
ADDITIONAL PRE-PLANT BURNDOWN OPTIONS – ENLIST VARIETIES ONLY						
Most weeds when *2,4-D* is mixed with *glyphosate*; may miss Carolina geranium, and Palmer amaranth should be < 3". ***Off-target movement of 2,4-D poses the greatest threat to the survival of this technology; steward these herbicides with the utmost level of respect or use alternative control methods.***	*2,4-D choline* Enlist One 3.8 S	4	24-32 fl oz	0.7-0.95	48 H/ N/a	**Enlist Varieties Only.** Label allows application any time prior to planting or behind planter. Regardless of labeling, all winter weeds and cover crops (exception could be cereal grains) should be killed at least 10 days prior to planting. GA data suggests the choline formulation of *2,4-D* has reduced volatility potential when compared to other *2,4-D* formulations. **Be certain to study the label regarding requirements for training, buffers, wind speeds, spray tip requirements, and boom heights. Also, one must review the website (**www.enlisttankmix.com**) for approved adjuvants, drift reduction agents, and tank mixtures.** ***Enlist Duo is no longer labeled in 11 GA counties, make certain it is labeled in your county prior to use.***
	glyphosate + *2,4-D choline* Enlist Duo	9 + 4	3.5-4.75 pt	0.74-1.0 (lb ae) + 0.7-0.95	48 H/ N/a	

WEED	HERBICIDE	MOA	BROADCAST RATE/aCRE		REI/PHI (Hours or Days)	REMARKS AND PRECAUTIONS
			AMOUNT OF FORMULATION	LBS ACTIVE (AI or AE)		
ADDITIONAL PRE-PLANT BURNDOWN OPTIONS – ENLIST VARIETIES ONLY *(continued)*						
Horseweed, fleabane, and most other weeds; research suggests this is the preferred treatment in Enlist cotton. *2,4-D* is needed to control emerged plants while Valor provides residual control. **Off-target movement of 2,4-D poses the greatest threat to the survival of this technology; steward these herbicides with the utmost level of respect or use alternative control methods.**	*2,4-D choline* Enlist One 3.8 S + *approved glyphosate* + *flumioxazin* Valor SX 51 WDG Valor EZ 4 SC	4 + 9 + 14	 24 to 32 fl oz + see *glyphosate* + 2 oz 2 fl oz	0.7-0.95 + 0.75-1.13 + 0.063	48 H/ N/a	**Enlist Varieties Only.** Enlist One label allows application anytime prior to planting; see and follow Valor plantback restrictions. GA data suggests the choline formulation of 2,4-D has reduced volatility potential when compared to other 2,4-D formulations. **Be certain to study the label regarding requirements for training, buffers, wind speeds, spray tip requirements, and boom heights. Also, one must review the website** (www.enlisttankmix.com) **for approved adjuvants, drift reduction agents, and tank mixtures.**
ADDITIONAL PRE-PLANT BURNDOWN OPTIONS – XTENDFLEX VARIETIES ONLY						
May not control geranium or spiderwort completely; Palmer amaranth should be < 3". **Off-target movement of dicamba poses the greatest threat to the survival of this technology; steward these herbicides with the utmost level of respect or use alternative control methods.**	*approved glyphosate* + *dicamba* Engenia 5 SL or XtendiMax 2.9 SL	9 + 4	*see glyphosate* + 12.8 fl oz or 22 fl oz	0.75-2.25 (lb ae) + 0.5	24 H/ N/a	***Dicamba* Tolerant Variety Only.** **Engenia and XtendiMax are Restricted Use Pesticides!** Can apply any time prior to planting or behind the planter. Regardless of labeling, all winter weeds and cover crops (exception could be cereal grains) should be killed at least 10 days prior to planting. Lower rate of glyphosate for annual weeds and higher rates for perennial weeds, see label. DO NOT INCLUDE AMS IN THIS MIX! **Be certain to study current requirements on the label regarding training, avoiding inversions, application cut-off dates (July 30), buffers (240 downwind if no adjacent sensitive crops/plants; 310 downwind + 57 omni-directional in ESA defined counties), wind speeds (wind speeds), sprayer speeds (ideal less than 10 mph, label has < 15 mph), and boom heights (24" above target).** **Also, review the website for required nozzle types, volatility reduction adjuvants or pH buffering adjuvants, drift reduction adjuvants, and approved tank mix partners (www.xtendimaxapplicationrequirements.com or www.engeniatankmix.com).**
Horseweed, fleabane, and most other weeds; preferred treatment in XtendFlex cotton. *Dicamba* is needed to control emerged resistant horseweed while Valor provides residual control.	*dicamba* Engenia or XtendiMax + *approved glyphosate* + *flumioxazin* Valor EZ 4 SC	4 + 9 + 14	 12.8 or 22 fl oz + see *glyphosate* + 2 fl oz	 0.5 + 0.75-2.25 + 0.063	24 H/ N/a	***Dicamba* Tolerant Variety Only.** **See all of the comments/requirement/restrictions in the row just above in the glyphosate + Engneia or XtendiMax tank mixture section.** Follow the plant back interval restriction for Valor in regards to this mixture as it is the most restrictive. Lower rate of glyphosate for annual weeds and higher rates for perennial weeds, see label. DO NOT INCLUDE AMS IN THIS MIX! ***Off-target movement of dicamba poses the greatest threat to the survival of this technology; steward these herbicides with the utmost level of respect or use alternative control methods.***

WEED	HERBICIDE	MOA	BROADCAST RATE/aCRE		REI/PHI (Hours or Days)	REMARKS AND PRECAUTIONS
			AMOUNT OF FORMULATION	LBS ACTIVE (AI or AE)		
PRE-PLANT INCORPORATED – ANY VARIETY						
Annual grasses, pigweeds and Florida pusley. Controls *glyphosate*-resistant Palmer amaranth much more effectively than when applied pre-emergence.	*pendimethalin* Prowl 3.3 EC Prowl H_20 3.8 AS	3	 1.2-2.4 pt 2 pt	 0.5-1 0.95	24 H/ N/a	Soil incorporate to a depth of 2" in moist soil ideally 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* thus is a better option if incorporation is delayed, delayed incorporation will reduce control. For Treflan 4 L, rate should not exceed 1.5 pt/a for most fields. The addition of a premeregence herbicide is critical.
	trifluralin Treflan, others 4 L	3	1-2 pt	0.5-1	12 H/ N/a	
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	12-16 fl oz	0.19-0.25	24 H/ N/a	**A Section 2 (ee) Georgia Label** allows a pre-plant application by incorporating Reflex to a 2" or less depth while the soil is moist; suggest including *pendimethalin* or *trifuruali*n. The addition of a preemergence 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 pre-emergence 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 PRE-PLANT INCORPORATED (PPI) FOLLOWED BY PRE-EMERGENCE (PRE) APPLICATIONS – ANY VARIETY						
The SINGLE MOST consistently effective approach for the control of Palmer amaranth; especially in dryland production. **For PPO-resistance management**, make only 3 applications of Valor or Reflex (including generics) on a field in 3 years.	**PPI:**					**PPI:** **A Section 2 (ee) Georgia label** allows shallow (2") incorporation to activate the herbicide; soil moisture is required for activation. Plant within 1 week of application and incorporation if possible. Numerous formulations of *fomesafen* are available; however, their labels likely do not support this use pattern.
	trifluralin or *pendimethalin* + *fomesafen* Reflex 2S	3 + 14	See rates in pre- plant incorporated + 10-12 fl oz	See rates in pre-plant incorporated + 0.16-0.19	24 H/ N/a	
	PRE:					**PRE:** 1. Be sure to include *paraquat* PRE if Palmer 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, research suggests the rate of *diuron* for most fields should not exceed 10 oz/a. Numerous formulations of *fomesafen* and *diuron* are available.
	fomesafen Reflex 2S + *acetochlor* Warrant 3ME OR *diuron* Direx, Diuron 4L	14 + 15 OR 7	 8-10 fl oz + 32 fl oz OR 10-20 fl oz	0.125-0.16 + 0.75 OR 0.31-0.63	24 H/ N/a	

WEED	HERBICIDE	MOA	BROADCAST RATE/aCRE		REI/PHI (Hours or Days)	REMARKS AND PRECAUTIONS
			AMOUNT OF FORMULATION	LBS ACTIVE (AI or AE)		
PRE-EMERGENCE WEED CONTROL – ANY VARIETY						
Residual control of annual grasses, Palmer amaranth, and tropical spiderwort.	*acetochlor* Warrant 3 ME	15	2-3 pt	0.75-1.125	12 H/ N/a	The manufacturer recommends 3 pt/a; however, UGA research suggests a rate of 2 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 or expecting heavy rains during the first 2 weeks of planting. Warrant should be applied in combination with *fomesafen* (Reflex, others), *diuron*, Brake, or Cotoran depending on Palmer population and technology grown; add *paraquat* and adjuvant if Palmer is up. Apply within 24 hours 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	36-48 fl oz	0.77-1.03 + 0.175-0.233	24 H/ N/a	Manufacturer recommends 48 to 60 oz/a; however, UGA research suggests 36 oz/a providing 2 pt/a of Warrant and 0.175 lb ai of fomesafen (equivalent to 11 oz/a of Reflex) when applying on light soil textures or when using intense irrigation or expecting heavy rains during the first 2 weeks after planting. Apply within 24 hr of planting; add *paraquat* plus adjuvant if Palmer is up.
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	0.38-0.78 lb 10-20 fl oz	0.31-0.62	12 H/ N/a	*Diuron* should be applied in combination with *fomesafen* (Reflex, others), Warrant, or Brake 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 but in general use lower rate on sandier soils and/or under intense irrigation. Label restricts use on soils with < 1% organic matter. Suggest avoiding *diuron and Cotoran* PRE if applied burndown within 21 days of planting. Numerous generic formulations are available.
Residual suppression of annual broadleaf weeds and annual grasses. The most effective single residual material for sicklepod, cocklebur, and morningglory control. Less effective than *diuron* on Palmer.	*fluometuron* Cotoran 4 L	7	2-3 pt	1-1.5	12 H/ N/a	Cotoran should be applied in combination with *fomesafen* (Reflex, others), Warrant, or Cotoran 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 use lower rate on sandier soils and/or with intense irrigation. A maximum of 2 pt/a is ideal for many GA soils.
Excellent residual control of Palmer amaranth when activated. In mixture with an effective tank mix partner, the combination can provide very broad weed control.	*fluridone* Brake 1.2 F	12	16-32 fl oz	0.15-0.3	48 H/ N/a	Tank mix Brake with another residual herbicide when using less than 21 oz/a. Research has noted 16 oz/a of Brake mixed with Reflex, Warrant, or diuron can be very effective. Data shows that if one does not mix Brake with another effective herbicide, Palmer amaranth will often emerge prior to Brake activation. Do not apply more than 2 years in a row in a field. Also study rotational restrictions on label; for rates of 16-21 oz/a carryover of 4 months for soybean, 8 months for wheat/rye/peanut, 12 months for corn/sorghum, and 18 months for sunflower, pepper, tomato, and tobacco is noted. Research notes Brake often requires 0.5 in. of irrigation or rainfall to become fully activated. Research also notes Brake is quite stable through heavy rains.

WEED	HERBICIDE	MOA	BROADCAST RATE/aCRE		REI/PHI (Hours or Days)	REMARKS AND PRECAUTIONS
			AMOUNT OF FORMULATION	LBS ACTIVE (AI or AE)		
PRE-EMERGENCE WEED CONTROL – ANY VARIETY *(continued)*						
Excellent residual for Palmer amaranth; good control of poinsettia and suppression of yellow nutsedge. For PPO resistance management, make only 3 applications of *fomesafen* or Valor (including generics) on a field in 3 years.	*fomesafen* Reflex, Dawn 2S	14	10-16 fl oz	0.16-0.25	24 H/ N/a	Reflex or generics should be applied in combination with Warrant, Diuron, Brake, or Cotoran depending on Palmer population and technology grown; add *paraquat* and adjuvant if Palmer is up. Apply within 24 hr of planting. The manufacturer recommends 1 to 1.5 pt/a on coarse textured soils; however, research suggests 12 oz/a is an appropriate rate when mixed with other effective residual herbicides on most soils; lower rates on lighter, low organic-matter soil and/ or when using intense irrigation. Injury more often occurs when initial rains or irrigation occurs as cotton is emerging. 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. Reflex and Dawn have been tested intensely; other brands are available.
Annual grasses and Florida pusley; suppression of Palmer amaranth only. Irrigation or rainfall needed within 24 hours.	*pendimethalin* Prowl 3.3 EC Prowl H20 3.8 AS	3	 1.5-2.4 pt 1.5-2 pt	 0.62-0.99 0.71-0.95	24 H/ N/a	Pre-emergence applications without immediate irrigation/rainfall are far less consistent than incorporated treatments; tank mixtures usually 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 (or generic)*. Apply within 24 hours of planting.
Controls non-ALS resistant pigweeds, lambsquarters, prickly sida, spurge, and smartweed. Suppresses morningglory, except tall.	*pyrithiobac* Staple LX 3.2 S	2	1.7-2.1 fl oz	0.0425-0.053	4 H/ N/a	Has excellent residual herbicide activity but cotton injury, especially on irrigated light textured soils, is a **serious concern**. Thus, one should consider a delayed PRE or early POST use of Staple. Do not apply on soils with less than 0.5% organic matter. Can tank mix with *diuron*, *Cotoran*, *pendimethalin*, or Reflex; apply within 24 hr of planting. Include *paraquat* or *glyphosate* if weeds are emerged.

WEED	HERBICIDE	MOA	BROADCAST RATE/aCRE		REI/PHI (Hours or Days)	REMARKS AND PRECAUTIONS
			AMOUNT OF FORMULATION	LBS ACTIVE (AI or AE)		
POST-EMERGENCE OVERTOP WEED CONTROL FOR ANY VARIETY						
Annual grasses Goosegrass must be less than 3 in. for adequate control.	*clethodim* Select, other 2 EC SelectMax 0.97 EC Tapout 0.97 EC	1	 6-8 fl oz 12-16 fl oz 12-16 fl oz	0.09-0.13	24 H/ 60 D	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 or crop oil concentrate 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	8-12 fl oz	0.125-0.188	12 H/ 90 D	
	quizalofop ethyl Assure II 0.88 EC	1	7-8 fl oz	0.05-0.06	12 H/ 80 D	
	Sethoxydim Poast 1.53 EC Poast Plus 1 EC	1	 16 fl oz 24 fl oz	0.19	12 H/ 40 D	
Perennial grasses	*clethodim* Select, others 2 EC Select Max 0.97 EC Tapout 0.97 EC	1	 8-16 fl oz 16-32 fl oz 16-32 fl oz	0.13-0.25	24 H/ 60 D	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 5 days of application.
	fluazifop p-butyl Fusilade DX 2 EC	1	10-12 fl oz	0.156-0.188	12 H/ 90 D	Apply when johnsongrass is 8-18” and before boot stage 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” or when bermudagrass stolon (runner) regrowth or new plants are 4-8”. 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.
	quizalofop p-ethyl Assure II 0.88 EC	1	10-12 fl oz	0.07-0.08	12 H/ 80 D	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; do not exceed 18 fl oz/a per year. 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	 24 fl oz 36 fl oz	0.28	12 H/ 40 D	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 6-12” 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.

WEED	HERBICIDE	MOA	BROADCAST RATE/aCRE		REI/PHI (Hours or Days)	REMARKS AND PRECAUTIONS
			AMOUNT OF FORMULATION	LBS ACTIVE (AI or AE)		
POST-EMERGENCE OVERTOP WEED CONTROL – ANY VARIETY						
Non-ALS resistant pigweed less than 1", morningglory (excluding tall mg), coffee senna, and redweed. At most, suppresses sicklepod. Provides good residual control of many species if it reaches the ground and is activated.	*Pyrithiobac* Staple LX 3.2 S	2	2.7-3 fl oz	0.06-0.07	4 H/ 60 D	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/100 gal spray mix. Label allows 2 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.	*Trifloxysulfuron* Envoke 75 WDG	2	0.1-0.15 oz	0.0047-0.007	12 H/ 60 D	Label allows directed or overtop application after cotton has at least 5 (prefer 7) true leaves up until 60 days of harvest at a rate of 0.1 to 0.15 oz/a. Sloppy directed application encouraged for less injury and improved weed coverage in larger cotton. 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. Rainfast in 3 hours. Provides some residual control of sensitive weeds if contacts soil and is activated.
Many broadleaf weeds. Poor control of tropic croton, copperleaf and ALS-resistant pigweed. Good residual of sensitive weeds if contacts soil and is activated.	*trifloxysulfuron* Envoke 75 WDG + *pyrithiobac* Staple LX 3.2 SL	2 + 2	0.1 oz + 1.3-1.9 fl oz	0.0047 + 0.03-0.05	12 H/ 60 D	Sloppy directed application encouraged for less injury and improved weed coverage on larger cotton. Label allows overtop or directed application after cotton has at least 5 (prefer 7) true leaves up until 60 days of harvest. Add nonionic surfactant at 1 qt/100 gal spray mix. See comments and restrictions for each product applied alone.

WEED	HERBICIDE	MOA	BROADCAST RATE/aCRE		REI/PHI (Hours or Days)	REMARKS AND PRECAUTIONS
			AMOUNT OF FORMULATION	LBS ACTIVE (AI or AE)		
POST-EMERGENCE OVERTOP WEED CONTROL FOR ENLIST, GLYTOL LIBERTYLINK, or XTENDFLEX VARIETIES ONLY						
Control of pusley, spiderwort, and goosegrass are not expected. 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". Do not tank mix with grass herbicides. **Suggest no more than 2 applications per year on a field**; include two herbicides PRE, residual mixtures POST, and a directed layby.	*glufosinate* Liberty 2.34S	10	29-43 fl oz	0.53-0.79	12 H/ 70 D	**Enlist, Glytol LibertyLink, or XtendFlex variety** Label allows application from emergence through early bloom; however, UGA data suggests applications should be directed after 8 leaf cotton to minimize injury 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. **A Section 24(c) Georgia Local Need Label** allows two applications as close as 5 days apart when Liberty is applied alone with a maximum rate of 36 oz/a; if using tank partners, the intervals should be at least 10 days. **To maximize control:** > 15 GPA water volume, thorough spray coverage, warm temperatures, high humidity, bright sunlight, good soil moisture, and do not spray within 1.5 hours of sunrise or 2 hours of sunset. Mixtures with residual herbicides are usually needed to assist in the control of grasses, pusley, spiderwort, and pigweed. Research has shown in some environments, especially saturated soils, injury from Liberty is greatest in XtendFlex cotton followed by Enlist cotton and least with Glytol LibertyLink cotton. Cheetah and Interline are formulations of *glufosinate* that have been tested; other brands are available. Rain fast within 4 hours.
Mixing *glyphosate* with Liberty will not influence control by Liberty; however, grass control will often be more than Liberty alone but less than that by *glyphosate* alone. Mixing Liberty with *glyphosate* can significantly reduce the control of pre-bloom wild radish compared to *glyphosate* alone.	*glufosinate* Liberty 2.34 S + *glyphosate* numerous brands	10 + 9	29-43 fl oz + see *glyphosate*	0.53-0.79 + 0.75-1.13 lb ae	12 H/ 70 D	**Enlist, Glytol LibertyLink, and XtendFlex variety** See comments for *glufosinate* and *glyphosate* alone. Injury on Glytol LibertyLink is almost always negligible; injury on Enlist and XtendFlex is often increased slightly above *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.
Staple may improve emerged pigweed control (non ALS-resistant) and provides residual activity on sensitive weeds if spray contacts soil and is activated.	*glufosinate* Liberty 2.34S + *pyrithiobac* Staple LX 3.2 SL	10 + 2	29-43 fl oz + 1.9 fl oz	0.53-0.79 + 0.03-0.05	12 H/ 70 D	**Enlist, Glytol LibertyLink, or XtendFlex variety** See information for *glufosinate* and *pyrithiobac* alone. 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.

WEED	HERBICIDE	MOA	BROADCAST RATE/aCRE		REI/PHI (Hours or Days)	REMARKS AND PRECAUTIONS
			AMOUNT OF FORMULATION	LBS ACTIVE (AI or AE)		
POST-EMERGENCE OVERTOP WEED CONTROL FOR ENLIST, GLYTOL LIBERTYLINK, or XTENDFLEX VARIETIES ONLY *(continued)*						
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 fully studied but early research is postitive. Dual and Outlook are activated more easily and quickly; 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". Injury level often increases as Liberty rate increases in these mixtures.	*glufosinate* Liberty 2.34S + *acetochlor* Warrant 3 ME	10 + 15	 29-43 fl oz + 2 pt	0.53-0.79 + 0.75	12 H/ 70 D or first bloom (most restrictive)	**Enlist, Glytol LibertyLink, or XtendFlex variety** See information above or labels for details on *glufosinate*. **Warrant** mixture can be applied from fully emerged cotton through early bloom; label allows rate up to 3 pt/a although injury is a concern at this rate. **Dual Magnum** mixture can be applied from fully emerged cotton through 100 days before harvest if applied overtop or 80 days before harvest if directed. **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. **To maximize control:** ≥ 15 GPA water volume, through spray coverage, warm temperatures, high humidity, bright sunlight, good soil moisture, and do not spray within 1.5 hours of sunrise or 2 hours 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*.
	glufosinate Liberty 2.34S + *S-metolachlor* Dual Magnum 7.62 EC	10 + 15	 29-43 fl oz + 1 pt	0.53-0.79 + 0.95	24 H/ 100 D	
	glufosinate Liberty 2.34S + *dimethenamid-P* Outlook 6 EC	10 + 15	 29-43 fl oz + 12-16 fl oz	0.53-0.79 + 0.56-0.75	12 H/ 70 D or 2nd week after initial bloom (most restrictive)	
POST-EMERGENCE OVERTOP WEED CONTROL FOR ENLIST, GLYTOL LIBERTYLINK, ROUNDUP READY FLEX, or XTENDFLEX VARIETIES						
Controls most annual weeds; exceptions include *glyphosate*- resistant Palmer amaranth, dayflower, Florida pusley, tropical spiderwort, doveweed, and hemp sesbania. Morningglory, nutsedge, and purslane can be challenging. Goosegrass is very difficult to control and must be less than 3 in. when treated. Rarely should glyphosate be applied alone.	*glyphosate* 4S (3 lb ae) 5.4S (4 lb ae) 5S (4.17 lb ae) 5.5S (4.5 lb ae) 5.88 S (4.88 lb ae) 6S (5 lb ae)	9	 32-48 fl oz 24-36 fl oz 23-34 fl oz 22-32 fl oz 21-30 fl oz 19-29 fl oz	0.75-1.13 (lb ae)	4 H/ 7 D	Roundup PowerMax 3 (4.88 lb ae) may be applied overtop or directed to ***Roundup Ready Flex*** technology anytime from cotton emergence until 7 days prior to harvest. The maximum rate for any single application (Roundup PowerMax 3) is between emergence and 60% open bolls is 30 fl oz (1.13 lb ae). Do not exceed a total of 120 fl oz (4.5 lb ae) applied from emergence through 60% open bolls. Do not exceed a maximum of 40 fl oz (1.55 lb ae) applied between layby and 60% open bolls. Do not exceed a maximum of 40 fl oz between 60% open bolls and harvest. **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 4) a directed layby including conventional chemistry.

WEED	HERBICIDE	MOA	BROADCAST RATE/aCRE		REI/PHI (Hours or Days)	REMARKS AND PRECAUTIONS
			AMOUNT OF FORMULATION	LBS ACTIVE (AI or AE)		
POST-EMERGENCE OVERTOP WEED CONTROL FOR ENLIST, GLYTOL LIBERTYLINK, ROUNDUP READY FLEX, or XTENDFLEX VARIETIES *(continued)*						
Warrant provides residual control of grasses, pigweeds, and tropical spiderwort, if it contacts the soil and is activated.	*glyphosate* + *acetochlor* Warrant 3 ME	9 + 15	see *glyphosate* + 2 pts	0.75-1.12 + 0.75	12 H/ do not apply after first bloom	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 topical or directed application can be made. Rate can be increased to 3 pt/a according to the label; this rate would be beneficial with directed applications without injury concern. Suggest using 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; more data needed on spiderwort.	*glyphosate* + *dimethenamid-P* Outlook 6 EC	9 + 15	see *glyphosate* + 12-16 fl oz	0.75-1.12 + 0.56-0.75	12 H/ 2nd wk after initial bloom	See comments for *glyphosate* alone. Label allows two applications as long as the first application is made prior to 10 leaf cotton and the second application is made prior to 2nd week after initial bloom; total use rate for year must not exceed 31 oz/a. Some leaf speckling/burn will likely occur. Avoid heavy dew on cotton plant, saturated soils, and extreme, hot conditions. UGA research suggests making directed applications after the 8-leaf stage to reduce injury potential while improving weed control.
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 3.2 SL	9 + 2	see *glyphosate* + 2-3 fl oz	0.75-1.12 + 0.05-0.07	4 H/ 60 D	See comments for *glyphosate* and Staple alone. Apply overtop from full 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 and for the control of emerged morningglory, a rate of 2.1 oz/a should perform well.

WEED	HERBICIDE	MOA	BROADCAST RATE/aCRE AMOUNT OF FORMULATION	BROADCAST RATE/aCRE LBS ACTIVE (AI or AE)	REI/PHI (Hours or Days)	REMARKS AND PRECAUTIONS
POST-EMERGENCE OVERTOP WEED CONTROL FOR ENLIST, GLYTOL LIBERTYLINK, ROUNDUP READY FLEX, or XTENDFLEX VARIETIES *(continued)*						
Metolachlor provides residual control of 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	9 + 15	see *glyphosate* + 1 pt	0.75-1.12 + 0.95	24 H/ 100 D	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. UGA research suggests making directed applications after the 8-leaf stage to reduce injury potential and improve weed control; if directing Dual Magnum rate could be increased to 1.33 pt/a without injury concerns. Some leaf speckling/burn will likely occur. Avoid heavy dew on cotton plant, saturated soils, and extreme, hot conditions. Do not mix with Staple or apply within 5 days of Staple.
	glyphosate + *S-metolachlor* Sequence 5.25L	9 + 15	2.5 pt	0.7 + 0.94	24 H/ 100 D	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 improves Ipomoea morningglory and nutsedge control. Also provides some residual control of sensitive weeds if it reaches the soil and is activated. Best option for control of non-STS soybean.	*glyphosate* + *trifloxysulfuron* Envoke 75 WDG	9 + 2	see *glyphosate* + 0.1 oz	0.75-1.12 + 0.0047	12 H/ 60 D	See comments for *glyphosate* and Envoke applied alone. Tank mix can be applied from 5 (prefer 7) leaf stage until 60 days of harvest; however, directed application strongly encouraged for improved weed control and much less injury. Label allows the rate of Envoke to be increased to 0.15 oz/a when applying overtop or directed. If applying topically, gain experience with a few acres first ensuring injury level is within your acceptable range. Will not control ALS + *glyphosate* resistant pigweed.
Volunteer Roundup Ready corn in Roundup Tolerant cotton Also, these mixtures should be considered for the control of goosegrass.	*glyphosate* + *clethodim* Select 2 EC Select Max 0.97EC	9 + 1	see *glyphosate* + 4-8 fl oz 8-16 fl oz	0.75-1.12 + 0.06-0.13	24 H/ 60 D	See comments for ***glyphosate*** alone. ***Clethodim****:* For corn up to 12" tall, apply 4-6 oz of Select or 8-12 oz of Select Max; for corn up to 24" tall, apply 6-8 oz of Select or 12-14 oz of Select Max; for corn up to 36" tall, apply maximum rates. Add 2.5 lb/a *ammonium sulfate* or equivalent and make sure *glyphosate* brand used contains adjuvant. ***Fusilade DX****:* Apply 4 oz Fusilade for corn less than 12". Increase rate to 6 oz for corn up to 24". Add 0.25% by volume of crop oil concentrate. ***Assure II****:* 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 + *fluazifop-p-butyl* Fusilade DX 2 EC	9 + 1	see *glyphosate* + 4-6 fl oz	0.75-1.12 + 0.06-0.09	12 H/ 90 D	
	glyphosate + *quizalofop-p-ethyl* Assure II 0.88 EC	9 + 1	see *glyphosate* + 5-8 fl oz	0.75-1.12 + 0.03-0.05	12 H/ 80 D	

WEED	HERBICIDE	MOA	BROADCAST RATE/aCRE		REI/PHI (Hours or Days)	REMARKS AND PRECAUTIONS
			AMOUNT OF FORMULATION	LBS ACTIVE (AI or AE)		
ADDITIONAL POST-EMERGENCE OVERTOP WEED CONTROL FOR ENLIST VARIETIES						
2,4-D is extremely effective on many broadleaf weeds including spiderwort and morningglory; pigweed needs to be less than 3" and sequential applications are often needed. This mixture may be less effective on grasses than *glyphosate* alone, especially with goosegrass and when grases are larger than 3 in. **Off-target movement of 2,4-D poses the greatest threat to the survival of this technology; steward these herbicides with the utmost level of respect or use alternatives.**	*2,4-D choline* Enlist One 3.8 S + approved *glyphosate* OR approved *glufosinate*	9	24-32 fl oz + see *glyphosate* OR see *glufosinate*	0.7-0.95 see *glyphosate* OR see *glufosinate*	48 H/ first bloom	**Enlist Varieties Only:** Enlist One or Enlist Duo are the only brands of *2,4-D* currently approved for this use. Apply anytime from cotton emergence to first bloom. May apply twice, allow 12 days between applications. Suggest both applications after the 8-leaf stage of cotton be directed for reduced drift, reduced injury potential and increased weed control. For Enlist One, label currently allows tank mixtures with several herbicides including some *glyphosate* and *glufosinate* products, Warrant, or Dual Magnum. GA data suggests the choline formulation of *2,4-D* has reduced volatility potential when compared to other *2,4-D* formulations. **Be certain to study the label regarding requirements for training, buffers, wind speeds, spray tip requirements, and boom heights. Also, one must review the website** (www.enlisttankmix.com) **for approved adjuvants, drift reduction agents, and tank mixtures.** ***Enlist Duo is no longer labeled in 11 GA counties, make certain it is labeled in your county prior to use.***
	glyphosate + *2,4-D choline* Enlist Duo 3.3 S	9 + 4	3.5-4.75 pt	0.74-1 (lb ae) + 0.7-0.95	48 H/ mid-bloom	
ADDITIONAL POST-EMERGENCE OVERTOP WEED CONTROL FOR XTENDFLEX VARIETIES						
Dicamba at 0.5 lb ai/a is extremely effective on many broadleaf weeds including morningglory; pigweed needs to be less than 3 in. and sequential applications are often needed. Tavium is a premix of *dicamba* + *S-metolachlor*. *S-metolachlor* will provide residual control of many small-seeded broadleaf weeds and grasses if activated in a timely manner. **Off-target movement of *dicamba* poses the greatest threat to the survival of this technology; steward these herbicides with the utmost level of respect or use alternatives.**	*dicamba* Engenia 5 S or XtendiMax 2.9 S + approved *glyphosate*	9 + 4	12.8 fl oz or 22 fl oz + see *glyphosate*	0.5 + see *glyphosate*	24H/ see remarks	**Dicamba Tolerant Varieties Only** **Engenia and XtendiMax are Restricted Use Pesticides:** Two in-crop applications can be made. Applications must be made in at least 15 gallons of water per acre. Separate sequential applications by at least 7 days. **Tavium is a Restricted Use Pesticide.** An in-crop application can be made over-the-top through 6-leaf cotton; minimum of 15 GPA of spray solution per acre. Significant injury has been noted in some environments, similar to previous experiences mixing these active ingredients. **Be certain to study current requirements on the label for Engenia, XtendiMax, and Tavium regarding training, avoiding inversions, application cut-off dates (July 30), buffers (240 downwind if no adjacent sensitive crops/plants; 310 downwind + 57 omni-directional in ESA defined counties), wind speeds (3-10 mph), sprayer speeds (ideal less than 10 mph, label has < 15 mph), and boom heights (24" above target).** **Also, review the website for required nozzle types, volatility reduction adjuvants or pH buffering adjuvants, drift reduction adjuvants, and approved tank mix partners (www.xtendimaxapplicationrequirements.com, www.engeniatankmix.com, or www.TaviumTankMix.com).**
	dicamba + *S-metolachlor* Tavium	4 + 15	56.48 fl oz	0.5 + 1.0	24H/ see remarks	

WEED	HERBICIDE	MOA	BROADCAST RATE/aCRE		REI/PHI (Hours or Days)	REMARKS AND PRECAUTIONS
			AMOUNT OF FORMULATION	LBS ACTIVE (AI or AE)		
POST-EMERGENCE DIRECTED – ANY VARIETY						
Control of many broadleaf weeds (including spiderwort) and nutsedge**;** residual control of many weeds if activated. Grasses should be < 1 in. or a *glyphosate* mixture would be in order. Grasses should be < 1". ***Diuron* plus *MSMA* is the best directed option to control emerged *glyphosate*-resistant Palmer amaranth.** *Diuron* is better on emerged pigweed than Caparol, Cotoran, or Valor. Valor provides more effective residual control of pigweed.	*diuron* Direx, Diuron, other 4L + *MSMA* (several brands) 6 lb/gal 6.6 lb/gal	7 + 17	 1.6-2.4 pt + 2 pt 2 pt	0.8-1.2 + 1.5-1.65	12 H/ 1st Bloom	Apply as directed spray to cotton at least 12" tall. Addition of crop oil concentrate is strongly encouraged. Label prohibits use on sand or loamy sand soils, or any soils with less than 1% organic matter. 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** Envoke at 0.1 oz/a which has no additional injury concern. **To improve spiderwort and grass residual control consider adding:** 1) Dual Magnum 1.0-1.33 pt/a; or 2) Warrant 2-3 pt/a; or 3) Zidua 4SC 1.25-2.5 fl oz/a with cotton having > 5 leaves; or 4) Outlook 12-16 fl oz/a Numerous formulations of *diuron* and *MSMA* are available.
Controls many broadleaf weeds and nutsedge; grasses should < 0.5". Palmer amaranth should be < 2". Residual control of many weeds if activated. If grasses are present, a *glyphosate* mixture would be in order. *Diuron* is better on emerged pigweed than Caparol, Cotoran, or Valor; however, Valor provides the best residual control by far.	*flumioxazin* Valor SX 51WDG Valor EZ 4 SC + *MSMA* (several brands) 6 lb/gal 6.6 lb/gal	14 + 17	 2 oz 2 fl oz + 2.67 pt 2.5 pt	0.064 + 2	12 H/ 1st Bloom	Apply as a directed spray to cotton at least 18" tall. Apply 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 with no crop contact. 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 crop contact occurs; consider the addition of Dual or Warrant for managing tropical spiderwort and Palmer amaranth. Outflank, Panther, and Rowel perform similarly to Valor. **For PPO-resistance management**, make only 3 applications of Valor or Reflex (including generics) on a field in 3 years.

WEED	HERBICIDE	MOA	BROADCAST RATE/aCRE		REI/PHI (Hours or Days)	REMARKS AND PRECAUTIONS
			AMOUNT OF FORMULATION	LBS ACTIVE (AI or AE)		
POST-EMERGENCE DIRECTED – ANY VARIETY *(continued)*						
The single best layby mixture for control of both emerged *glyphosate*-resistant Palmer amaranth and extended residual control. Grass must be < 0.5". Be careful, mixture is "hot".	*flumioxazin* Valor SX 51 WDG Valor EZ 4 SC + *diuron* Direx, others 4L + *MSMA* (several brands) 6 lb/gal 6.6 lb/gal	14 + 7 + 17	 2 oz 2 fl oz + 1 pt + 2 pt 2 pt	0.064 + 0.5 + 1.5 1.65	12 H/ 1st Bloom	Cotton should be at least 20" tall. Apply as a directed spray to the lower 2" of the barky portion of the cotton stem. Do not contact any green portion of the 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 < 0.5" and Palmer < 2". Will not improve control of emerged weeds compared to *flumioxazin* + *MSMA* but better residual control is likely.	*flumioxazin* + *pyroxasulfone* Fierce 76 WDG Fierce EZ 2.04 SC + *MSMA* 6 lb/gal 6.6 lb/gal	14 + 15 + 17	 3 oz 6 fl oz + 2.67 pt 2.5 pt	0.063+0.08 + 2	12 H/ 1st Bloom	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 as long as no crop contact. 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, nutsedge, and small annual grasses. Residual control of many weeds. Less effective than *diuron* mix for emerged pigweed and less residual on pigweed than *diuron* or Valor but safer to the cotton.	*fluometuron* Cotoran 4L + *MSMA* (several brands) 6 lb/gal 6.6 lb/gal	7 + 17	 2-3.2 pt + 2.67 pt 2.5 pt	1-1.6 + 2	12 H/ 1st Bloom	Apply as a directed spray to cotton at least 3" tall; cotton has very good tolerance. Label suggests the need for 0.5% v/v of surfactant and prohibits applying *MSMA* after 1st bloom. **To improve emerged morningglory and nutsedge control consider adding** Envoke at 0.1 oz/aafter cotton reaches the 5 leaf stage. **To improve spiderwort, pigweed, and grass residual control consider adding:** 1) Dual Magnum 1.0-1.33 pt/a; or 2) Warrant 2-3 pt/a; or 3) Zidua 4 SC 1.25-2.5 fl oz/a with cotton having >5 leaves; or 4) Outlook 12-16 oz/a
Effective control of many broadleaf weeds, nutsedge, and small annual grasses. Less effective than *diuron* mix in controlling emerged pigweed and less residual on pigweed than *diuron* or Valor.	*prometryn* Caparol 4L + *MSMA* (several brands) 6 lb/gal 6.6 lb/gal	5 + 17	 1.3-2.4 pt + 2.67 pt 2.5 pt	0.65-1.2 + 2	12 H/ 1st Bloom	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 *MSMA* after 1st bloom. **To improve emerged morningglory and nutsedge control consider adding** Envoke at 0.1 oz/a after cotton has reached the 5 leaf stage. **To improve spiderwort, pigweed, and grass residual control consider adding:** 1) Dual Magnum 1.0-1.33 pt/a; or 2) Warrant 2-3 pt/a; or 3) Zidua 4 SC 1.25-2.5 fl oz/a with cotton having >5 leaves; or 4) Outlook 12-16 oz/a

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

WEED	HERBICIDE	MOA	BROADCAST RATE/aCRE		REI/PHI (Hours or Days)	REMARKS AND PRECAUTIONS
			AMOUNT OF FORMULATION	LBS ACTIVE (AI or AE)		
POST-EMERGENCE DIRECTED – ENLIST, GLYTOL LIBERTY LINK, ROUNDUP READY FLEX, OR XTENDFLEX VARIETIES						
Controls most annual weeds; exceptions include resistant Palmer amaranth, dayflower, doveweed, Florida pusley, tropical spiderwort, and hemp sesbania. Morningglory and purslane can be challenging. Goosegrass is very difficult to control and must be < 3 in.	*glyphosate* 4 S (3 lb ae) 5.4S (4 lb ae) 5S (4.17 lb ae) 5.5S (4.5 lb ae) 5.88S (4.8 lb ae) 6S (5 lb ae)	9	 32-48 fl oz 24-36 fl oz 23-34 fl oz 22-32 fl oz 21-30 fl oz 19-29 fl oz	0.75-1.12 lb ae	4 H/ 7 D	*Glyphosate* should never be applied alone. 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; 3) residual herbicides with Roundup POST; and 4) a directed layby including conventional chemistry.
Mixing *diuron* with *glyphosate* improves morningglory and Palmer amaranth control; although morningglory control may still not be acceptable. Also provides residual control of some broadleaf weeds, such as pigweed. The tank mix may give less grass control than *glyphosate* alone.	*glyphosate* + *diuron* Direx, Diuron 4L	9 + 7	see *glyphosate* + 1-1.5 pt	0.75-1.12 + 0.5-0.75	12 H/ 7 D	Use 1 pt/a of *diuron* on cotton 8-12" and up to 1.5 pt/a of *diuron* on cotton greater than 12". Label prohibits the use of diuron on sand or loamy sand soils, or any soils with less than 1% organic matter. **To improve spiderwort, pigweed, and grass residual control consider adding*:*** 1) Dual Magnum 1-1.33 pt/a; 2) Warrant 2-3 pt/a; 3) Zidua 4 SC 1.25-2.5 oz/a with cotton having >5 leaves; or 4) Outlook 12-16 oz/a. **To improve morningglory and nutsedge control consider adding** Envoke 0.1 oz/a with no additional restrictions. **To improve morningglory control and provide excellent residual control of many weeds consider adding** Valor 1–1.5 oz/a, cotton should be at least 18" tall with spray contacting only bottom 2" of barky stem. Residual Palmer control by *diuron* at this rate often lasts 7-10 days.
Mixing Valor with *glyphosate* improves morningglory, spiderwort, and Palmer amaranth control and provides residual control of many broadleaf weeds including pigweeds, purslane, and Florida pusley. Often poor control of *glyphosate*-resistant Palmer amaranth over 1" but excellent residual control.	*glyphosate* + *flumioxazin* Valor SX 51WDG Valor EZ 4 SC	9 + 14	see *glyphosate* + 1-2 oz 1-2 fl oz	0.75-1.12 + 0.031-0.063	12 H/ 60 D	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 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 post-emergence control as *glyphosate* + Valor but provides greater residual control for many weeds including spiderwort and Palmer amaranth.	*glyphosate* + *flumioxazin* + *pyroxasulfone* Fierce 76 WDG Fierce EZ 3.04 SC	9 + 14 + 15	see *glyphosate* + 3 oz 6 fl oz	0.75-1.12 + 0.063 + 0.08	12 H/ 60 D	Cotton should be 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 as long as no crop contact. 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.

WEED	HERBICIDE	MOA	BROADCAST RATE/aCRE		REI/PHI (Hours or Days)	REMARKS AND PRECAUTIONS
			AMOUNT OF FORMULATION	LBS ACTIVE (AI or AE)		
POST-EMERGENCE DIRECTED – ENLIST, GLYTOL LIBERTY LINK, ROUNDUP READY FLEX, OR XTENDFLEX VARIETIES *(continued)*						
Mixing Caparol with *glyphosate* improves morningglory control and provides residual control of sensitive species; although morningglory must still be small for adequate control. The tank mix may give less grass control than *glyphosate* alone.	*glyphosate* + *prometryn* Caparol 4L	9 + 5	see *glyphosate* + 1-2 pt	0.75-1.12 + 0.5-1	12 H/ –	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 1-1.33 pt/a; 2) Warrant 2-3 pt/a; 3) Zidua 4 SC 1.25-2.5 oz/a with cotton having >5 leaves; or 4) Outlook 12-16 oz/a. **To improve morningglory and nutsedge control consider adding:** Envoke 0.1 oz/a, no additional restrictions. **To improve morningglory control and improve residual control of many weeds consider adding** Valor 1–1.5 oz/a, cotton should be at least 18" tall with spray contacting only bottom 2" of barky stem. Occasionally, directed applications to succulent cotton stems cause chlorosis from *prometryn* throughout the plant.
Mixing Anthem Flex with *glyphosate* will improve control of morningglory and spiderwort while providing residual control of sensitive species.	*glyphosate* + *pyroxasulfone + carfentrazone* Anthem Flex 4 Se	9 + 15 + 14	see *glyphosate* + 1.36–2.7 fl oz	0.75–1.12 + 0.04 + 0.003–0.079 + 0.006	12 H/ 7 D	Suggest cotton at least 18 in. (label allows application as long as cotton is over 12 in.; see label). Direct spray to the lower 2" of a barky cotton stem; do not contact the green portion of the cotton stem, foliage, or blooms. Limited UGA research, gain experience before significant use.
Mixing Envoke with *glyphosate* improves *Ipomoea* morningglory, non-STS soybeans, and nutsedge control and provides some residual control of sensitive species.	*glyphosate* + *trifloxysulfuron* Envoke 75 WDG	9 + 2	see *glyphosate* + 0.1-0.2 oz	0.75-1.12 + 0.005-0.009	12 H/ 60 D	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* will improve control of emerged pigweed.

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

WEED	HERBICIDE	MOA	BROADCAST RATE/aCRE		REI/PHI (Hours or Days)	REMARKS AND PRECAUTIONS
			AMOUNT OF FORMULATION	LBS ACTIVE (AI or AE)		
POST-EMERGENCE – HOODED ROW MIDDLE – ANY CULTIVAR						
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) 5.88 (4.8 lb ae) 6S (5 lb ae)	9	32-48 fl oz 24-36 fl oz 23-34 fl oz 22-32 fl oz 20-30 fl oz 19-29 fl oz	0.75-1.12	4 H/ 7 D	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, Fierce, Staple, Valor, Warrant or Zidua should be mixed with *glyphosate* to improve weed control. Follow application restrictions as provided on labels.
Annual grass and broadleaf weeds; suppression of nutsedge. Mixtures with *diuron* would be the most effective option to control emerged pigweed and most other broadleaf weeds in row middles.	*paraquat* 2 SL 3 SL	22	19-38 fl oz 13-21 fl oz	0.3-0.6	24 H/ 3 D	SALVAGE APPLICATION! DO NOT CONTACT COTTON STEMS OR FOLIAGE. **EPA has restricted the use of *paraquat* to certified applicators ONLY and applicators must take a specialized training before use.** 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* mixed with *paraquat* will likely improve control of emerged weeds and provide residual control. **If *paraquat* contacts the cotton stem severe damage is to be expected!**
Timing for pigweed and grasses are critical. Control of pusley, spiderwort, and goosegrass is usually not good. Generally, treat broadleaf weeds prior to 3" and grasses prior to 2". Excellent control of morningglory including moonflower morningglory. *Diuron* plus *MSMA* or *paraquat* is more effective on Palmer.	*glufosinate-ammonium* Liberty 2.34 S	10	29-43 fl oz	0.53-0.79	12 H/ 70 D	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, thorough spray coverage, warm temperatures, high humidity, bright sunlight, good soil moisture, and do not spray within 1.5 hours of sunrise or 2 hours of sunset. Numerous other brands of *glufosinate* are available. **For resistance management:** Suggest no more than 2 applications of glufosinate in a field per year.

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

WEED	HERBICIDE	MOA	BROADCAST RATE/aCRE		REI/PHI (Hours or Days)	REMARKS AND PRECAUTIONS
			AMOUNT OF FORMULATION	LBS ACTIVE (AI or AE)		
HARVEST AID						
Mature morningglory	*carfentrazone-ethyl* Aim 2 EC	14	up to 1.5 fl oz	up to 0.024	12 H/ 7 D	Apply as a harvest aid when 60-70% of the cotton bolls are open AND when the morningglory are mature (seedpods are visible). See label for addition of adjuvant and repeat applictions. See cotton defoliation section for potential negative influence on defoliation activity.
	pyraflufen ethyl ET 0.208 EC	14	up to 2.75 oz	up to 0.0044	12 H/ 7 D	Apply as a harvest aid when 60-70% of the cotton bolls are open AND when the morningglory are mature (seedpods are visible). See label for addition of adjuvant. See cotton defoliation section for potential negative influence on defoliation activity.
Desiccation of most weeds. Regrowth of many weeds occurs soon after application.	*paraquat* Gramoxone 3SL	22	0.7-1.3 pt	0.26-0.487	24 H/ 3 D	**EPA has restricted the use of *paraquat* to certified applicators ONLY and applicators must take a specialized training before use.** Defoliate cotton as normal. After at least 85% 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 10 GPA understanding 20 GPA will likely be far more effective. Label suggests waiting 3-7 days after defoliation to minimize leaf sticking. 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. ***Be aware of potential pine tree and other sensitive crop/plant injury with drift.***
Annual grasses and broadleaf weeds	*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) 5.88 S (4.8 lb ae) 6 S (5 lb ae)	9	 32-64 fl oz 24-48 fl oz 23-46 fl oz 22-44 fl oz 21-40 fl oz 19-38 fl oz	0.75-1.5 (lb ae)	4 H/ 7 D	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. May apply in cotton with RR Flex Technology up until 7 days before harvest. Will not improve defoliation of tolerant cotton.

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

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* + Reviton[5]	*glyphosate*[2] + Valor SX[6]	*paraquat*	*paraquat* + Direx[7]
GRASSES / SEDGES											
annual bluegrass	N	E	E	E	E	E	E	E	E	G-E	E
bermudagrass	N	F	F	F	F	F	F	F	F	P	P
crabgrass	N	E	G-E	G-E	E	G	E	E	E	F-G	G
goosegrass	N	F	F	P-F	F	P-F	F	F	F	P-F	F
Italian ryegrass	N	F-G	F	F	F-G	F	F-G	F-G	F-G	F	F
johnsongrass	N	G-E	G	G	G-E	F-G	G-E	G-E	G-E	P	P
little barley	N	E	E	E	E	E	E	E	E	G	G-E
sandbur	N	E	G-E	G-E	E	G	E	E	E	G	G
Texas panicum	N	E	G-E	G-E	E	G	E	E	E	G	G-E
volunteer corn - *glyphosate* resistant	N	N	N	N	N	N-P	N	N	P	F	F-G
purple nutsedge	N	F-G	F-G	F	F-G	F-G	F-G	F-G	G	P-F	F
yellow nutsedge	N	F	P-F	P-F	F	F	F	F	F	P-F	F
BROADLEAVES											
bristly starbur	G	E	E	E	E	E	E	E	E	E	E
buttercup	G	E	E	E	E	E	E	E	E	E	E
Carolina geranium	F	P-F	F-G	G	F-G	G	G-E	F	G	G-E	E
chickweed	P	E	E	E	E	E	E	E	E	E	E
citronmelon	F	G-E	E	E	E	G-E	G-E	G-E	E	F	G
cocklebur	E	E	E	E	E	E	E	E	E	G-E	E
coffee senna	G	E	E	E	E	E	E	E	E	F	G
corn spurry	P-F	G-E	G-E	G-E	G-E	G-E	G-E	G-E	E	F-G	G-E
cowpea	G	E	E	E	E	E	G-E	E	E	E	E
cudweed	P	E	E	E	E	E	E	E	E	F-G	G
curly dock	P-F	F	F-G	G	F	P-F	E	F	F	N-P	P
cutleaf primrose	E	P-F	E	G	F	F-G	F	F-G	F-G	F[8]	G-E[8]
eclipta	P	G-E	E	E	G-E	G-E	G-E	G-E	G-E	F	F

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* + Reviton[5]	*glyphosate*[2] + Valor SX[6]	*paraquat*	*paraquat* + Direx[7]
	BROADLEAVES *(continued)*										
Florida beggarweed	P-F	E	E	E	E	E	E	E	E	E	E
Florida pusley	F	P-F	G	G	G	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	G-E	G[8]	E[8]
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	G-E	F-G	E	E	G-E	G-E				F-G	G
morningglory, *Ipomoea*	G-E	F	E	E	E	G	F	E	E	F-G	G-E
morningglory, smallflower	F-G	G	E	E	G-E	G-E	G		E	P	F-G
Palmer amaranth	F	E	E	E	E	E	E	E	E	F-G	G-E
Palmer amaranth (*glyphosate*-resistant)	F	N	F-G	F-G	P-F	G	P	F	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	G	F-G	F-G	F-G			P-F	F-G
purslane	G	F	G-E	G-E	F-G	G	F		G	G	G-E
ragweed	E	G	E	E	G-E	G		G-E		G	G
redweed	F	G	G-E	G-E	G-E	G				F	G
shepherdspurse	G	G		G	G					G	G

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

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

[1] Application rates per acre: Xtendimax or Engenia (dicamba): 0.5 lb ai/a; 2,4-D: 1 pt; Aim: 1 oz; ET: 1-2 oz; diuron: 0.5-1.0 lb ai; glyphosate: 1.12 lb ae; paraquat: 0.75-1.0 lb ai; Harmony Extra TotalSol: 0.75 oz; Reviton 1-2 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] Apply 2,4-D at least 30 days ahead of planting, except for varieties with the Enlist trait where planting can occur any time after application.

[4] Following application of dicamba and a minimum of 1" of rainfall, a minimum 21-day waiting period before planting is required for non-tolerant varieties.

[5] Harmony Extra should be applied up to 21 days depending on soil type, prior to planting. Reviton should be applied 7 days prior to planting at 1 oz/a and 14 days for 2 oz/a.

[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 (3.8 lb ai per gallon 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* + Reviton[5]	*glyphosate*[2] + Valor SX[6]	*paraquat*	*paraquat* + Direx[7]
BROADLEAVES *(continued)*											
sicklepod	F-G	G-E	E	E	G-E	E	G-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	F	Aim = G-E ET = P-F	G-E	P		G	G	G-E
velvetleaf	F-G	G			G-E	G				P	P
vines (maypop, trumpet creeper)	F	P-F			P-F	F				P	P
Virginia pepperweed	G-E	G	E	G-E	G	G	G		G-E	G	G
volunteer peanuts	P	P-F	P-F	F-G	F-G	F-G	F	P-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	E-G	G	G	E	G	G	F-G	G-E
COVER CROPS											
clover	F	F	F-G	G-E	F	F-G		G	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	E	G[11]	G-E[11]
vetch	E	F	E	E	F	F-G	G		F-G	P-F[8]	F-G[8]

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

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

[1] *Application rates per acre: Xtendimax or Engenia (dicamba): 0.5 lb ai/a; 2,4-D: 1 pt; Aim: 1 oz; ET: 1-2 oz; diuron: 0.5-1.0 lb ai; glyphosate: 0.75-1.12 lb ae; paraquat: 0.75-1.0 lb ai; Harmony Extra TotalSol: 0.75 oz; Reviton 1-2 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] *Apply 2,4-D at least 30 days ahead of planting, except for varieties with the Enlist trait, where planting can occur any time after application.*

[4] *Following application of dicamba and a minimum of 1" of rainfall, a minimum 21-day waiting period before planting is required for non-tolerant cotton.*

[5] *Harmony Extra should be applied up to 21 days depending on soil type, prior to planting. Reviton should be applied 7 days prior to planting at 1 oz/a and 14 days for 2 oz/a.*

[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 (3.8 lb ai per gallon 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	PRE-PLANT INCORPORATED	PRE-EMERGENCE							
	Prowl, Treflan, others	Prowl[1]	Brake + Reflex	Command	Cotoran	Direx	Reflex	Staple	Warrant
PERENNIALS									
bermudagrass	N	N	N	P-F	N	N	N	N	N
johnsongrass (rhizome)	P	P	N	N	N	N	N	N	P
yellow nutsedge	N	N	F-G	N	N	N	F-G	F	N-P
purple nutsedge	N	N	P	N	N	N	P	F	N-P
ANNUAL GRASSES									
broadleaf signalgrass	G	F	F-G	E	P	P	F	P	G
crabgrass	E	G	F-G	E	F-G	F	F	P	E
crowfootgrass	E	G		G	F-G	F	F		E
fall panicum	G	F-G	F	G-E	F	P	F	P-F	G
foxtails	E	G		E	F-G		F	P	E
goosegrass	E	G		E	F	F	F	P-F	E
johnsongrass (seedling)	E	G		G	P	P	F	F-G	F
sandbur	E	G		F-G	G	G	F		F-G
Texas panicum	G	F		F	P	P	F	N	P-F
ANNUAL BROADLEAVES									
bristly starbur	N	N	G-E	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	G	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	P	F-G	P
crotalaria	N	N			G	G			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 on average to good soil and weather conditions for herbicide performance and on 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 RESPONSE TO HERBICIDES USED IN COTTON *(continued)*

WEED SPECIES	PRE-PLANT INCORPORATED	PRE-EMERGENCE							
	Prowl, Treflan, others	Prowl[1]	Brake + Reflex	Command	Cotoran	Direx	Reflex	Staple	Warrant
ANNUAL BROADLEAVES *(continued)*									
eclipta	P	P	G-E		G		G-E		
Florida beggarweed	P	P		F-G	G-E	G	P	G	P
Florida pusley	E	F-G		F-G	P-F	P	F	G	G-E
hemp sesbania	N	F		P	P	P	P	P	N
jimsonweed	N	N		G	G	G		F-G	N
lambsquarters	G-E	G	E	G	G-E	G-E	E	G	P-F
morningglories									
Ipomoea	P	P	F	P-F[2]	G	F	P-F	F[3]	P
smallflower	P	P	G-E	P	G-E	G	G	E	P
Palmer amaranth	F-G	P-F	E	N-P	P-F	F-G	E	G-E[3]	G
pigweed: redroot or smooth	G-E	F-G	E	P	G	G	E	E	G-E
prickly sida	N	N	G	E	G	F		G	P-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	N	N	F	N	G	G		G	
Pennsylvania	N	N	F	E	G	G		G	
sicklepod	N	N	P	P	F-G	F	P	P-F	P
spurge	N	N		N	P-F	F		G	P-F
tropic croton	N	N	G	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	G-E	F	N	N	G-E	G	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 on average to good soil and weather conditions for herbicide performance and on 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 RESPONSE TO HERBICIDES USED IN COTTON *(continued)*

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-E	F	P-F	G-E
hemp sesbania	P	P		P
jimsonweed		F-G		
lambsquarters	P-F	G		P-F
morningglories				
Ipomoea	P	F[3]		P
smallflower	P	E	P-F	P
Palmer amaranth	G	G-E[3]	P-F	G
pigweed: redroot or smooth	G-E	G-E	F	G-E
prickly sida	P-F	G		P-F
purslane	G	G		G
ragweed	P	N-P		P
redweed		G-E		
smartweed:				
ladysthumb		G		
Pennsylvania		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

Key:
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Note: Ratings based on average to good soil and weather conditions for herbicide performance and on 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 RESPONSE TO HERBICIDES USED IN COTTON *(continued)*

WEED SPECIES	POST OVER-THE-TOP								
	Assure	Fusilade	Poast	Select/Select Max	*MSMA*	Cotoran	Staple	Envoke	Envoke + Staple
PERENNIALS									
bermudagrass	G	G	F	G	N	N	N	N	N
johnsongrass (rhizome)	E	G-E	G	G-E	P	N	N-P	P	N-P
purple nutsedge	N	N	N	N	N-P	N	P-F	F-G	F-G
yellow nutsedge	N	N	N	N	P	N	P-F	G	G
ANNUAL GRASSES									
broadleaf signalgrass	G	G-E	E	E	P	P	N	N	N
crabgrass	G	G	G-E	G-E	P	P-F	N	P	P
crowfootgrass	G	F	F-G	G	P	P-F	N	N	N
fall panicum	G-E	G-E	E	E	P	P-F	N	N-P	P
foxtails	E	E	E	E			N-P	N-P	N-P
goosegrass	F	F	F	F	P	P	N-P	N-P	N-P
johnsongrass (seedling)	E	G-E	G-E	E	P	P	P	P	P-F
sandbur		G	G	G	P	P	P		
Texas panicum	G	G	E	E	N-P	N	N	N-P	P
ANNUAL BROADLEAVES									
bristly starbur	N	F-G	N	N	P	G	G	G-E	G-E
burgherkin	N	N	N	N	P-F	F-G	G		
citronmelon	N	N	N	N	P-F	G	G-E	G-E	G-E
cocklebur	N	N	N	N	E	F-G	G	G-E	E
coffee senna	N	N	N	N	P-F	F-G	G		
cowpea	N	N	N	N	F	F-G	G	G	G-E
crotalaria	N	N	N	N	F	G			
eclipta	N	N	N	N			G	P-F	
Florida beggarweed	N	N	N	N	E	G	G	G-E	G-E
Florida pusley	N	N	N	N	N-P	P-F	N-F	P	P
hemp sesbania	N	N	N	N			G-E		

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

WEED RESPONSE TO HERBICIDES USED IN COTTON *(continued)*

WEED SPECIES	POST OVER-THE-TOP								
	Assure	Fusilade	Poast	Select/Select Max	*MSMA*	Cotoran	Staple	Envoke	Envoke + Staple
ANNUAL BROADLEAVES *(continued)*									
jimsonweed	N	N	N	N	P	G	E	N	
lambsquarters	N	N	N	N	P	G	N	G	
Ipomoea morninglories	N	N	N	N	P-F	F-G	G[1]	G	G-E
Smallflower morningglory	N	N	N	N	P-F	G	E	N	E
Palmer amaranth	N	N	N	N	N-P	P-F	F	P-F	F
Palmer amaranth (ALS resistant)	N	N	N	N	N-P	N	N	N	N
pigweed: smooth and redroot	N	N	N	N	N-P	F	G	F-G	G
prickly sida	N	N	N	N	P	F-G	F	N	F
purslane	N	N	N	N	P-F	F-G	F		
ragweed	N	N	N	N	P-F	G	P	G	
redweed	N	N	N	N	N	F-G	G		
sicklepod	N	N	N	N	P-F	F-G	P-F	E	E
smartweed:									
ladysthumb	N	N	N	N	N-P	F-G	G	G	
Pennsylvania	N	N	N	N	N-P	F-G	G	G	
spider flower	N	N	N	N		F			
spurge	N	N	N	N	N	P-F	F-G		
tropic croton	N	N	N	N	F	F-G	P	P-F	P-F
tropical spiderwort	N	N	N	N	P	P	P	P-F	F
volunteer peanuts	N	N	N	N	P	F	P	P-F	
wild poinsettia	N	N	N	N	P	F	F	G	

Key:
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F – 60-80% control P – 30-60% control N – < 30% control.

[1] Staple does not control tall morningglory.

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

WEED RESPONSE TO HERBICIDES USED IN COTTON *(continued)*

WEED SPECIES	POST OVER-THE-TOP							
	Liberty	**Liberty + Enlist One**	**Liberty + Staple**	***glyphosate***	***glyphosate* + *2,4-D choline***	***glyphosate* + Engenia or XtendiMax**	***glyphosate* + Staple**	***glyphosate* + Envoke**
PERENNIALS								
bermudagrass	N	N	N	F	F	F	F	F
johnsongrass (rhizome)	F[1]		F[1]	G-E	G-E	G-E	G-E	G-E
purple nutsedge	P	P	P-F	F-G	F	F	F-G	G-E
yellow nutsedge	P	P	P-F	F	F	P-F	F-G	G-E
ANNUAL GRASSES								
broadleaf signalgrass	G	G	G	E	E	G-E[2]	E	E
crabgrass	G	G	G	E	E	G-E[2]	E	E
crowfootgrass	G	G	G	E	E	G-E[2]	E	E
fall panicum	G	G	G	E	E	G-E[2]	E	E
foxtails	G	G	G	E	E	G-E[2]	E	E
goosegrass	P	P	P	F	F	P-F[2]	F-G	F-G
johnsongrass (seedling)	G	G	G	E	E	G-E[2]	E	E
sandbur	G	G	G	E	E	G-E[2]	E	E
Texas panicum	G	G	G	E	E	G-E[2]	E	E
ANNUAL BROADLEAVES								
bristly starbur	G	G-E	G-E	E	E	E	E	E
burgherkin				G-E	E	E	G-E	G-E
citronmelon	G	G-E	G-E	G-E	E	E	E	E
cocklebur	E	E	E	E	E	E	E	E
coffee senna	G	G-E	G-E	E			E	E
cowpea	G	E	E	E	E	E	E	E
crotalaria		G	G	G			G	G
eclipta	G	E	E	E	E	E	E	E
Florida beggarweed	G	G	G-E	E	E	E	E	E

Key:

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N – < 30% control.

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

[1] Johnsongrass control can be obtained with two applications of Liberty.

[2] Grass must be less than 3 in. for this level of control.

WEED RESPONSE TO HERBICIDES USED IN COTTON *(continued)*

WEED SPECIES	POST OVER-THE-TOP							
	Liberty	**Liberty + Enlist One**	**Liberty + Staple**	***glyphosate***	***glyphosate* + *2,4-D choline***	***glyphosate* + Engenia or XtendiMax**	***glyphosate* + Staple**	***glyphosate* + Envoke**
ANNUAL BROADLEAVES *(continued)*								
Florida pusley	F	G	F	F-G	G	G	F-G	F-G
hemp sesbania	G-E	E		P-F	E	E	G-E	
jimsonweed	E	E	E	E	E	E	E	E
lambsquarters	E	E	E	G	E	E	G	E
Ipomoea morninglories	E	E	E	F-G	E	E	G-E	E
Smallflower morningglory	E	E	E	G	E	E	E	G
Palmer amaranth	F-G	G-E	G	E	E	E	E	E
Palmer amaranth (*glyphosate*-resistant)	F-G	G-E	G	N	G	G	F	P-F
Palmer amaranth (*glyphosate*- and ALS-resistant)	F-G	G-E	G	N	G	G	N	N
pigweed: smooth and redroot	G	E	G-E	E	E	E	E	E
prickly sida	F-G	G	F-G	F-G	G	G	F-G	G
purslane	F	F-G	F-G	F-G	G	G	G	G
ragweed, common	E	E	E	E	E	E	E	E
redweed				E			E	
sicklepod	E	E	E	E	E	E	E	E
smartweed: ladysthumb Pennsylvania	G-E G-E	G-E G-E	G-E G-E	G G	G G	E E	E E	E E
spider flower								
spurge	F-G			G	G		G	G
tropic croton	G	E	G	E	E	E	E	E
tropical spiderwort	P	G-E	G	F	G-E	F	G	F-G
volunteer peanuts	G	G	G-E	F-G	G	E	G	F-G
wild poinsettia	P	G	F	G-E			G-E	E

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N – < 30% control.

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

WEED RESPONSE TO HERBICIDES USED IN COTTON *(continued)*

WEED SPECIES	POST-EMERGENCE-DIRECTED						
	MSMA	Cotoran + *MSMA*	Caparol + *MSMA*	Direx + *MSMA*	Cobra + *MSMA*	Valor + *MSMA*	Diuron + *MSMA* + Envoke
PERENNIALS							
bermudagrass	N	N	N	N	N	N	N
johnsongrass (rhizome)	P	P	P	P	P	P	P
purple nutsedge	F	F	F	F	F	F-G	E
yellow nutsedge	F-G	F-G	F-G	G	F-G	G	E
ANNUAL GRASSES							
broadleaf signalgrass	F	F	F	F-G	P-F	F	F-G
crabgrass	F	F	F-G	F-G	P-F	F	F-G
crowfootgrass	F	F	F-G	F-G	P-F	F	F-G
fall panicum	F	F	F-G	F-G	P-F	F	F-G
foxtails	F	F	F-G	F-G	P-F	F	F-G
goosegrass	F	F	F-G	F-G	P-F	F	F-G
johnsongrass (seedling)	F	F	F-G	F-G	P-F	F	F-G
sandbur	F	F	F-G	F-G	P-F	F	F-G
Texas panicum	P	P	F	F	P	P-F	F
ANNUAL BROADLEAVES							
bristly starbur	P-F	G	G	G	G	G	G-E
burgherkin	F	F-G	G	G	G		
citronmelon	F	G	F-G	G	G		G-E
cocklebur	E	E	E	E	E	E	E
coffee senna	F	G	G	G	F	G	
cowpea	F-G	G	G	G	F-G	G	E
crotalaria	G	G	G	G	G		E
eclipta		G	G	E	E	E	E
Florida beggarweed	E	E	E	E	E	E	E

WEED RESPONSE TO HERBICIDES USED IN COTTON *(continued)*

WEED SPECIES	POST-EMERGENCE-DIRECTED						
	MSMA	**Cotoran + *MSMA***	**Caparol + *MSMA***	**Direx + *MSMA***	**Cobra + *MSMA***	**Valor + *MSMA***	**Diuron + *MSMA* + Envoke**
ANNUAL BROADLEAVES *(continued)*							
Florida pusley	P	F	F	F	F	F-G	F-G
hemp sesbania	N	P-F	P-F	P-F	F		
jimsonweed	F	G-E	G	G	G-E	E	G
lambsquarters	P-F	G	G	G	F	F-G	G-E
morningglories	P-F	F-G	G	G	E	E	E
Palmer amaranth	P	F	F	G-E	F	F-G	G-E
pigweed: redroot or smooth	P-F	G	G	G-E	G	G-E	E
prickly sida	P	F-G	G-E	G-E	G-E	G-E	G-E
purslane	P-F	F-G	F-G	G	G	G	G-E
ragweed, common	F	G-E	E	E	E	G-E	E
redweed	N	F-G	G	G-E	F		
sicklepod	F	G	G-E	G-E	P-F	G-E	E
smartweed: ladysthumb and Pennsylvania	P	G	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)		
spurge	N	P-F	G	G	G	G	
tropic croton	F	G	G	G	E	E	G-E
tropical spiderwort	F	G	F-G	G-E	F-G	G-E	E
volunteer peanuts	P-F	F-G	F-G	G	P-F	F-G	G
wild poinsettia	P-F	F	P-F	P-F	G	G	

Key: E – 90% or better control; G – 80-90% control; F – 60-80% control; P – 30-60% control; N – < 30% control

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

WEED RESPONSE TO HERBICIDES USED IN COTTON *(continued)*

WEED SPECIES	POST-EMERGENCE-DIRECTED						
	glyphosate	*glyphosate* + Direx	*glyphosate* + Direx + Envoke	*glyphosate* + Diuron + Dual Magnum	*glyphosate* + Valor	Liberty	HOOD Gramoxone + Direx
PERENNIALS							
bermudagrass	F	F	F	F	F	N	P
johnsongrass (rhizome)	G-E	G	E	G	G-E	F	P
purple nutsedge	F-G	F-G	G-E	F-G	F-G	P	P-F
yellow nutsedge	F	F	G-E	F-G	F-G	P	P-F
ANNUAL GRASSES							
broadleaf signalgrass	E	G-E	G-E	E	E	G	G-E
crabgrass	E	G-E	G-E	E	E	F-G	G
crowfootgrass	E	G-E	G-E	E	E	G	G
fall panicum	E	G-E	G-E	E	E	G	G
foxtails	E	G-E	G-E	E	E	G	G
goosegrass	F	F	F	F-G	F-G	P	G
johnsongrass (seedling)	E	G-E	E	G-E	E	G	G
sandbur	E	G-E	G-E	G-E	E	G	G
Texas panicum	E	G-E	E	E	E	G	G
ANNUAL BROADLEAVES							
bristly starbur	G-E	G-E	G-E	G-E	E	G	E
burgherkin	G	G	G	G			F
citronmelon	G-E	G-E	E	E	E	G	G
cocklebur	E	E	E	E	E	E	G
coffee senna	E	E	E	E	E	G	F
cowpea	G-E	G-E	E	G-E	E	G	G
crotalaria	G	G	G	G			
eclipta	E	E	E	E	E	G	F
FL beggarweed	E	E	E	E	E	G	E
Florida pusley	P-G	G	G-E	G-E	G-E	F	P-F
hemp sesbania	P-F						

WEED SPECIES	POST-EMERGENCE-DIRECTED						
	glyphosate[1]	*glyphosate* + Direx	*glyphosate* + Direx + Envoke	*glyphosate* + Direx + Dual Magnum	*glyphosate* + Valor	Liberty	HOOD Gramoxone + Direx
ANNUAL BROADLEAVES *(continued)*							
jimsonweed	E	E	E	E	E	E	G
lambsquarters	G	G-E	G-E	G-E	G-E	E	F
morningglory - *Ipomoea*	F-G	G	E	G	E	E	F-G
morningglory - smallflower	G	E	E	E	E	E	P-F
Palmer amaranth	E	E	E	E	E	F-G	G-E
Palmer amaranth (*glyphosate*-resistant)	N	G	G	G-E	P-F	F-G	G-E
Palmer amaranth (*glyphosate* & ALS resis.)	N	G	G	G-E	P-F	F-G	G-E
pigweed: redroot or smooth	E	E	E	E	E	G	G-E
prickly sida	F-G	G	G	G	G-E	F-G	P-F
purslane	F-G	G-E	G-E	G-E	G-E	F-G	G
ragweed, common	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	G-E
smartweed	G	G	E	G	G	G-E	G
spider flower					G		
spurge	G	G-E	G-E	G-E	G	F-G	
tropic croton	E	E	E	E	E	G	F
tropical spiderwort	P-F	G	G-E	G-E	G-E	P-F	G-E
volunteer peanuts	F	G	G	G	F-G	G-E	P
wild poinsettia	G	G	E	G	G-E	P-F	G

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

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 technology systems and packages that will be available in 2024. The predominant technology systems that will be available in 2024 include (but aren't necessarily limited to) conventional, Widestrike Roundup Ready Flex (WRF), Bollgard II Xtendflex (B2XF), Widestrike 3 Enlist (W3FE), Bollgard III Xtendflex (B3XF), Bollgard III Thryvon Xtendflex (B3TXF), and Axant Flex (GLIXTP). In variety "names" there is a set of letters after the name which designate technologies (See table below). For example, DP 1646 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 have illustrated that several varieties can perform 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.

The average lifespan of cotton varieties is becoming 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

Guide to Abbreviations for Cotton Technologies in Variety Nomenclature*

Abbreviation	Trait Name	Description
W	Widestrike	Two-gene caterpillar trait (Cry1Ac + Cry1F)
W3	Widestrike III	Three-gene caterpillar trait (Cry1Ac + Cry1F + Vip3A)
FE	Enlist	2,4-D Tolerant**, Glyphosate Tolerant, Glufosinate Tolerant
TP	TwinLink Plus	Three-gene caterpillar trait (Cry1Ac + Cry2Ae + Vip3A)
GLIX	Glytol Liberty Link Isoxaflutole Xtend	Glyphosate Tolerant, Glufosinate Tolerant, Isoxaflutole Tolerant**, Dicamba Tolerant**
B2	Bollgard II	Two-gene caterpillar trait (Cry1Ac + Cry2Ab)
B3	Bollgard III	Three-gene caterpillar trait (Cry1Ac + Cry2Ab + Vip3A)
XF	XtendFlex	Dicamba Tolerant**, Glyphosate Tolerant, Glufosinate Tolerant
T	Thryvon	Insect tolerance – Thrips and Tarnished Plant Bugs

*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 herbicdes and traits.

UGA Cotton website (www.ugacotton.com). Small-plot UGA Official Variety Trial (OVT) data is also available at the UGA Cotton website as well as http://www.swvt.uga.edu/. 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 on the UGA Cotton website. 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. Contact your local UGA County Extension agent for the most up-to-date information on variety performance and selection.

PLANTING DATES

Long term research has shown little yield difference in planting dates between April l and May 25. However, 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. Therefore, producers are encouraged to consider spreading risks by utilizing a range of planting dates each year.

Soil temperature is an important consideration for early planting. Generally, planting can safely proceed when the 4-in. soil temperatures reach 65 °F for 3 days and warming conditions are projected over the next several days (or approximately 50 DD-60s 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 temperatures 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 one's crop in this way is not advised. The adoption of on-board module building pickers has allowed many growers to harvest peanuts and cotton simultaneously, 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. Season-long weather--particularly rainfall--continues to be the single greatest factor influencing yield.

Planting cotton at the end of May and during early-June can prove to be successful, yet there are significant risks that are associated with later plantings. It should be noted that with regard to planting dates, long-term observations have shown that reaching maximum yield potential is much more predictable with planting dates prior to the end of May than compared to later dates. The primary issue is related to maturation of the crop in a timely manner (or reaching full maturation prior to cool temperatures in the fall). With later planting dates, any delay in maturation may ultimately result in reduced yield potential and the "room for error" is considerably smaller. Irrigation can reduce some of the risk, due to the ability to ensure quick germination and stand establishment as well as reducing maturity delays associated with episodic drought which often occur during the growing season in Georgia. Another considerable issue with planting in late-May and early-June is centered on replanting. Although replanting is not something we expect to do, each year, especially in dryland situations, there are fields which need to be replanted for one reason or another. Planting the crop for the first time late in the planting window limits if not eliminates the opportunity to replant and maintain maximum yield potential. Planting the crop for the first time in April or early-May allows for adequate time to replant if necessary.

Overall, we are fortunate in Georgia to have such a wide window to plant cotton and be successful. Producers should make plans to take advantage of this by spreading risks by planting their crop over a range of dates. Spreading out planting dates limits the impact of episodic drought events, boll rot conditions, thrips injury at planting, seedling disease, etc. from taking a toll on the entire crop. Spreading planting dates can to some degree help with timely harvest, which can affect overall lint yields and will more than likely improve fiber quality. Be sure to contact your local UGA County Extension Agent for more information on optimum planting dates (especially for information surrounding the annual impact of planting dates and thrips management).

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):

- 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.
- 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.

- 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
- 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.
- Avoid crop injury by over-the-top sprays or other misuse of herbicides to prevent stress and delayed maturity.
- Prevent fruit shed and fruiting gaps by good insect control, balanced nutrition, and irrigation.
- 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.
- 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.
- Use mepiquat-containing plant growth regulators if needed to prevent excess vegetative growth and boll rot, and to promote earliness.

Use ethephon (Prep, Finish, First Pick, etc.) harvest aid to promote boll opening, allow earlier harvest, and avoid freeze damage.

PLANT POPULATIONS / SEEDING RATES

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 to 2.5 seed/ft is a reasonable trade-off for economizing with the high price of cotton seed. 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 10 to 12 in. Reducing seeding rates below 2 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 maximized 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. Further 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 studies conducted during 2017 and 2018 has shown that when the same populations are achieved in both situations there is not statistical difference in yield. For example, the 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 in. wide. Wet beds may need to be leveled 1 to 4 hours ahead of planting. Equip planters with 6 to 8 in. wide depth bands or gauge wheels, or 12 to 16 in. wide gauge shoes to provide seed depth control and smooth drill area. Set planters to place seed 0.5 to 1 in. 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.

Performing pre-plant planter checks and ensuring proper planter setup can help minimize planting mistakes that can affect stand establishment. Seed meters should be checked regularly before and during the planting season. Any worn or damaged part in the meter should be replaced as it can affect seed singulation (plant population) by causing skips or multiples. Check seed tubes before planting to make sure they are clean and free of any obstructions. Opening-discs need to checked for correct blade diameter and sharpness. Replace disc-openers that are worn by more than 0.5 in. as they can result in shallower planting depths. Seed depth variations are common between the planter row-units so make sure to dig the seeds behind every planter row and check the planted seed depth. Soil type and field condition can also influence seed depth, therefore any changes in soil type or field condition would require additional depth checks to ensure correct planting depth. Recent planter studies have demonstrated that planter downforce needs to be adjusted for prevalent soil texture and field conditions (conventional, strip-till or no-till) to attain a more uniform and consistent seed depth throughout the field. Planting in a heavy textured soil or fields conditions where excessive crop residue (especially planting in cover crops) is present would require an additional downforce to attained the desired seeding depth.

When planting cotton in conservation systems, utilizing a single-disc coulter and a pair of row-cleaners in front of opening disks can help in cutting and removing any excessive soil or crop residue and provide a clean furrow to plant seeds. Coulter is normally adjusted so that it operates at a slightly shallower depth (about ¼") than the opening discs to prevent loosening soil around the furrow and creating any air pockets. Similarly, row-cleaners need to be adjusted so that they are barely touching the soil surface to remove the clods or residue and not digging into the soil.

If "rip-plant" equipment is used, off-set row drill 2 to 3 in. 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 in. 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 in. 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 in.

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 in. 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 included 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 exist, 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.

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:

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

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-60s]. 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 website (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 chart here 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 here: http://www.ugacotton.com/vault/file/UGA-Ext.-Pub.-Cotton-Growth-Development-2004.pdf.

From Planting to:	DD-60s	Days
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 main-stem 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 main-stem 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 main-stem 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 main-stem 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 variety, may develop in excess of 25 nodes or main-stem 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 main-stem 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

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

Height/Node Ratio (HNR). Average plant height divided by total main-stem nodes = HNR or Vigor Index (in./node).

Crop Stage	Vigor Index (Height/Node Ratio)		
	Normal	Stressed	Vegetative
Seedling cotton =	0.5 to 0.75	—	—
Early squaring =	0.75 to 1.2	0.7	> 1.3
Large square to 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

Ideal Plant (in very general terms):

- Height = 44 to 50 in.
- 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

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

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 great emphasis on fiber quality with respect to variety selection 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 should help alleviate this issue), and our reluctance to push the crop toward rapid defoliation, boll opening, and harvest. Ginning can also have a profound effect 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 deposits 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.

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 opportunity 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.

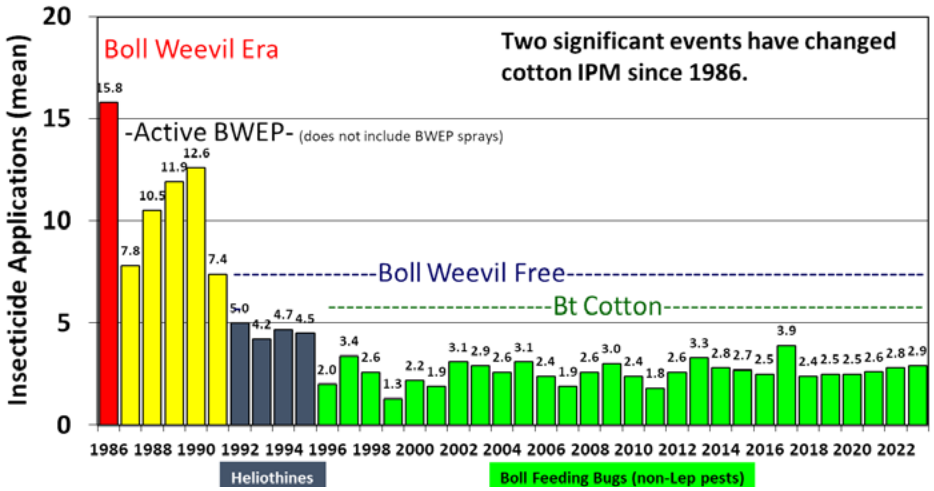

Figure 16. Mean Insecticide Applications Applied on Georgia Cotton, 1986 –2023. The Boll Weevil Eradication Program was Initiated During the Fall of 1986, Insecticide Applications Applied By BWEP Personnel Are Not Included in the Mean Insecticide Applications.

Scouting

Insect scouting is a **necessity**. All fields 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. 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 and mid-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. See UGA Extension publication C 1161, *Visual Reference Guide to Common Predators and Pests in Georgia Cotton* (https://extension.uga.edu/publications/detail.html?number=C1161) for more information.

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 insect 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 whiteflies and spider mites.

Insecticide 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). In furrow liquid applications of imidacloprid or acephate and in furrow applications of aldicarb granules (AgLogic 15G) at planting are also options and provide increased control of thrips compared with seed treatments.

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

ThryvOn is a new transgenic trait which significantly reduces thrips injury. We have conducted field trials with ThryvOn for several years and have never observed a planting which would benefit from a supplemental foliar insecticide for thrips control. ThryvOn does not result in high levels of thrips mortality, however thrips feeding and egg laying are significantly reduced. Typically, we observe about a 50 percent reduction in actual thrips numbers when scouting and sometimes we observe populations exceeding the threshold in ThryvOn cotton. However, we rarely see significant plant injury even if very high thrips infestations are present (i.e. above the threshold of 2-3 thrips per plant with immatures present). For this reason, it is important that we DO NOT make decisions to treat ThryvOn for thrips based on insect counts. **The threshold for thrips on ThryvOn cotton is treat if excessive plant injury is present and immature thrips are present.** Again, based on research in Georgia and across the Cotton Belt, we do not expect ThryvOn cottons to require supplemental foliar sprays for thrips.

It is important that we do not confuse thrips injury with other confounding symptoms associated with herbicide injury or sand blasting. Dr. Scott Graham, Auburn Extension Entomologist, in cooperation with Extension Entomologist across the Southeast recently published Maximizing Insect Control in ThryvOn Cotton in the Southeast. This publication covers both thrips and plant bug management in ThryvOn (https://www.aces.edu/blog/tag/maximizing-insect-control-in-thryvon-cotton-in-the-southeast/).

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 (1-2 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 have historically provided similar levels of thrips control and are active on thrips for 14–21 days after planting. However, imidacloprid seed treatments have provided more consistent control of thrips compared with thiamethoxam seed treatments in recent years. 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 an in-furrow liquid have provided improved control of thrips and longer residual when compared with seed treatments.

Acephate is an organophosphate and is an alternative 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 compared 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.

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 considered at the 1-leaf stage in conventional tilled fields planted prior to May 10 when a neonicotinoid 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. A more precise assessment of anticipated thrips infestations and plant injury can be

obtained when using the Thrips Infestation Predictor for Cotton tool found online at: https://products.climate.ncsu.edu/ag/cottontip/.

The Thrips Infestation Predictor for Cotton (TIPs) Tool uses planting date, temperature, precipitation, and knowledge of when and how intense thrips infestations will be to predict risk of thrips injury to cotton for specific geographic locations. Plant injury from thrips is a function of thrips pressure and seedling growth. The TIPs tool can be used to identify planting dates which are at greatest risk for thrips injury. High risk planting dates will require more aggressive thrips management compared with low risk planting dates to achieve acceptable thrips control. Management options for high risk planting dates would include the use of in-furrow liquid insecticides such as acephate or imidacloprid, in-furrow applications of aldicarb, planting a ThryvOn variety, or the use of a neonicotinoid seed treatment plus a supplemental foliar application at the 1-leaf stage. In low thrips risk environments neonicotinoid seed treatments will generally provide acceptable control. The TIPs tool should allow proactive decisions to be made relative to thrips management.

The TIPs tool will give the best predictions within 10-14 days after you use it, so use at multiple times during the planting and thrips management season would be beneficial. A description of the TIPs tool and how to run the tool can be found on the TIPs website. Dr. George Kennedy, NCSU entomologist, has prepared the webinar "Thrips Infestation Predictor for Cotton: An Online Tool for Informed Thrips Management". The webinar includes an overview and how to use the TIPs tool and can be found at: http://www.plantmanagementnetwork.org/edcenter/seminars/cotton/ThripsInfestationPredictor.

The TIPs tool is a predictive model based on many years of data from across the southeast and has been validated several years since. However, there will be uncertainty with any forecast model. But we are confident that the TIPs tool, when used as instructed, will accurately forecast thrips risk for cotton. The TIPs tool will not replace scouting and sampling for thrips and thrips injury in cotton, but it does provide information which will improve our thrips management programs.

Aphid Management

Cotton aphid is a consistent and predictable pest of cotton in Georgia. Aphids will typically build to moderate to high numbers and eventually crash due to a naturally occurring fungus, *Neozygites fresenii*. This fungal epizootic typically occurs in late June or early-mid 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 are able to tolerate more aphid damage than stressed plants.

Cotton leafroll dwarf virus (CLRDV) was detected in Georgia cotton during 2018. This virus is transmitted by cotton aphids. Field trials have been conducted each year since detection to examine the impact of aphid control on the incidence of CLRDV. Weekly applications of recommended insecticides will not eliminate aphids from cotton and will not significantly reduce incidence of CLRDV plants compared with untreated cotton. Research efforts are ongoing to better understand this virus and potential impacts.

Tarnished Plant Bug and Clouded Plant Bug Management

Tarnished plant bug has long been considered an occasional pest of cotton in Georgia and the lower Southeast. However, plant bug infestations have been more common in recent years. The risk of plant bug infestations in cotton appear to be associated with planting date, earlier planted cotton (April and early May planted) tends to

be at greater risk of plant bug infestations compared with later planted cotton. This is likely due to the presence of squares (feeding sites) when plant bugs are migrating from wild host plants during June.

Primary damage caused by plant bugs is feeding on small (pinhead) squares in plant terminals. However, plant bugs may also feed on large squares, small bolls, and terminals. Plant bugs insert their needle like piercing sucking mouthparts into fruiting forms and feed on the plant juices. After a pinhead square has been damaged, it turns yellow to brown or black and easily falls from the plant when disturbed. Healthy undamaged squares will be firmly attached to the plant. When the square is shed by the plant, an elliptical scar where the square was attached remains. No visible damage is apparent on the outer surface of squares damaged by plant bugs. Plant bug feeding in the terminal may alter the physiology and result in a malformed plant. Large squares which are damaged will often remain on the plant, however when the square blooms the flower will have warty growths on the petals and localized discoloration on the anthers. This type of flower damage is referred to as a "dirty bloom". Plant bugs may also feed on small bolls. Excessive feeding may cause boll shed, but most often localized lint and seed damage is the result. Callous warty growths on the inner surface of the boll wall will often form near the feeding site (appears very similar to stink bug damage).

Plant bugs and damage should be monitored from the time plants begin squaring through mid-bloom. Square retention counts are often used to detect problems with plant bugs. Inspect one pinhead square in the terminal of plants, note if it is good or bad/missing and report the percentage of healthy green squares retained by plants. Pinhead squares should be present when cotton has 6-8 nodes. They will be found at the base of the leaf petioles where they are attached to the mainstem in the top of the plant. The small square sits atop a short stem which will ultimately elongate into a fruiting branch. Our goal for plant bug management programs is to maintain 80 percent first position retention when we enter first bloom. Sweep nets (15 in. in diameter) are a good tool to monitor adult plant bugs in squaring cotton. As cotton enters bloom, a drop cloth or beat sheet is a better tool for plant bug scouting as it is more efficient in detecting immature plant bugs. Sweep nets and/or drop cloths should be used in addition to square retention counts to make the most informed decisions on plant bug management. Additionally whole plants should be examined periodically during the year to monitor overall fruit retention. Again, our goal is to maintain 80 percent retention of fruiting sites as we enter bloom.

Clouded plant bugs feed in a similar manner as tarnished plant bugs but tend to occur later in the season and are more likely to feed on small bolls. Clouded plant bugs should be scouted using the same methods as tarnished plant bug. Square retention counts can be used prior to bloom. When using a sweep or drop cloth each clouded plant bug should be counted 1.5 X as a tarnished plant bug. For example, 2 clouded plants bugs (2 x 1.5 = 3) would be counted as 3 tarnished plant bugs. Add the counts together for clouded and tarnished plant bugs and use the recommended tarnished plant bug threshold. For boll feeding, we should detect injury when assessing internal boll damage for stink bugs. Insecticides which control tarnished plant bugs and stink bugs will also control clouded plant bugs.

Plant bug insecticides should only be used when thresholds are exceeded. This is especially important during squaring and early bloom as this is a critical time when beneficial insects are establishing in the field. Disruption of natural controls with plant bug insecticide applications will increase the risk of problems with other pests such as corn earworm, mites, and whiteflies.

ThryvOn and Plant Bugs: In addition to thrips, ThryvOn also has activity on tarnished plant bugs. Insecticide resistance and other changes in the landscape have increased plant bug pressure in some areas of the southeast. Like thrips, adult avoidance plays a role in the reduced plant bug populations and limited injury in ThryvOn cotton. In addition to feeding less, adult plant bugs likely deposit fewer eggs in ThryvOn. However, threshold populations and economic damage from tarnished plant bugs in ThryvOn cotton have been observed. As a result, growers must maintain scouting activities for plant bugs in ThryvOn cotton and be prepared to make timely insecticide applications if thresholds are exceeded. Dr. Scott Graham, Auburn Extension Entomologist, in cooperation with Extension Entomologist across the Southeast recently published Maximizing Insect Control in ThryvOn Cotton in the Southeast. This publication covers both thrips and plant bug management in ThryvOn (https://www.aces.edu/blog/tag/maximizing-insect-control-in-thryvon-cotton-in-the-southeast/).

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 and Bt cottons 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).

Corn Earworm Pyrethroid Resistance

Susceptibility of CEW to pyrethroid insecticides has declined and become more erratic in some areas of the United States during recent years. Changes in susceptibility of corn earworm to pyrethroids have likely occurred in Georgia, but we have not experienced field control problems in cotton which may be due to low CEW infestations in Bt cotton; actually, few pyrethroids have targeted CEW for control in any row crop during recent years. However, there were several reports of difficulty controlling CEW in sweet corn in 2023. All attempts at management of CEW in sweet corn rely heavily on pyrethroid insecticides, along with multiple other chemistries. We have monitored susceptibility of CEW to pyrethroids for many years using adult vial tests (see below) and CEW have shown a steady increase in survival over time. To further investigate this potential problem, we cooperated with Dr. Stormy Sparks and collected CEW larvae from sweet corn ears on the UGA Tifton Campus in September 2023 and ran a bioassay with a pyrethroid insecticide, Lannate, and Radiant.

Dr. Greg Payne, University of West Georgia, provides us with pyrethroid treated vials to monitor susceptibility of CEW to pyrethroids using an Adult Vial Test (AVT). These assays have a quick turnaround time. To conduct AVTs, moths are collected from pheromone traps and placed in pyrethroid treated vials (cypermethrin 5 µg/vial) and mortality is evaluated 24 hours later. Figure 17 illustrates the seasonal mean survival of CEW in AVTs conducted from 2006-2023. We observed high survival during recent years. Note that survival during 2007 was 29 percent and in that year, we did experience some issues with control of CEW with pyrethroids in the field on single Bt gene Bollgard cotton. Survival since 2014 exceeds that observed in areas where field control problems occurred in 2007 and spiked to 48 percent survival in 2016. Beginning in 2017 we began testing a higher rate, 10µg/vial, in addition to the 5 µg/vial rate. Increased survival suggests that populations will be more difficult to control with a field application of a pyrethroid insecticide. Figure 17 clearly illustrates significant increases in survival at the high rate which suggest populations are losing susceptibility to the pyrethroid.

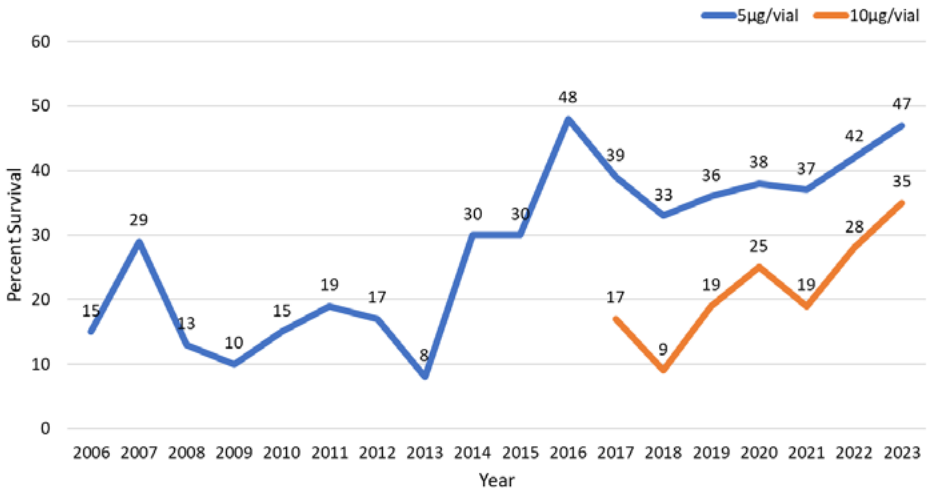

Figure 17. Seasonal mean survival of CEW in Adult Vial Tests 2006-2022 (cypermethrin 5 µg/vial and 10 µg/vial).

Results from the CEW insecticide bioassay are also concerning. We bioassayed a pyrethroid, Lannate and Radiant at 0.5, 1, and 2X rates using a leaf dip method. We observed 43, 43, and 60 percent mortality of CEW with the pyrethroid at 72 hours after treatment for the 0.5, 1, and 2X rates respectively. Lannate and Radiant provided 97 and 100 percent CEW mortality at the 1X rate. Although we did not have a susceptible population for comparison, these data strongly suggest a potential problem with pyrethroid resistance. While approximately half of the population appears susceptible, the half that survived the bioassay did so even at the highest rate tested, suggesting that individuals with resistance are potential highly resistant.

Current recommendations for control of corn earworm include the use of high rates of pyrethroids (recommended with caution). Performance of pyrethroids used for CEW management may vary due to insecticide resistance. 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.

Bt Cotton Management and Corn Earworm Susceptibility to Bt Cotton

Commercially available Bt cotton technologies include Bollgard 2, WideStrike, Twinlink, Bollgard 3, WideStrike 3, 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 pests such as corn earworm. 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 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, susceptibility of CEW to Bt cotton has significantly declined in the US. Corn earworm populations in Georgia are resistant to Cry1Ac (the first Bt gene). It also appears that CEW is much less susceptible (somewhat resistant) to the second gene (Cry2A). Additionally, researchers have seen reduced efficacy in 2-gene Bt corn in Georgia and other areas of the southeast. The Cry1F has never been very active on CEW, thus the reduced performance rating for WideStrike. 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; this is due to low corn earworm infestations in cotton. During 2022 we observed high CEW populations in a single field of 3-gene Bt cotton. Bt cotton must be scouted on a regular basis and growers must be prepared to act accordingly if thresholds are exceeded. Three-gene Bt cottons such as Bollgard 3, WideStrike 3, and TwinLink Plus provide improved control of CEW compared with two-gene Bt cottons. Bt cottons are not immune to caterpillar pests and require that proper IPM principles and practices are employed.

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.

Insect Pest Response (Control) to Bt Technologies in Cotton.

Bt Traits	Tobacco Budworm	Corn Earworm
Bollgard 3 (Cry1Ac + Cry2Ab + Vip3A)	+++	+++
TwinLink Plus (Cry1Ab + Cry2Ae + Vip3A)	+++	+++
WideStrike 3 (Cry1Ac + Cry1F + Vip3A)	+++	+++
Bollgard II (Cry1Ac + Cry2Ab)	+++	++
TwinLink (Cry1Ab + Cry2Ae)	+++	++
WideStrike (Cry1Ac + Cry1F)	+++	++

0 = none, + = fair, ++ = good, and +++ = very good

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, clouded plant bug, and leaf-footed bugs may injure developing bolls.

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

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

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 ft 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.

Silverleaf Whitefly Management

Historically silverleaf whitefly (SLWF) is a localized pest requiring management in a relatively small geographic area. Typically, SLWF infestations are most common in areas which produce **both** cotton and vegetables.

SLWF adults resemble tiny small white moths. Eggs are laid on the underside of leaves near the terminal. The first instar nymph is called a crawler. This crawler stage is the only immature stage which is mobile and only moves a short distance on the bottom of the leaf in search of a suitable place to feed. The crawler attaches itself to the leaf and the remainder of the immature stages are spent at this spot. Immature SLWF are oval and flattened in appearance and translucent to yellowish in color. On cotton during the summer, SLWF complete a generation in as little as 15 days. Development time is slowed when temperatures are cooler.

SLWF adults and immatures feed with sucking mouthparts. Damage ranges from reduced plant growth and vigor, general leaf decline, honeydew deposits on leaves and open cotton (honeydew accumulation on lint will negatively impact fiber quality and may impact spinning efficiency at mills), and premature defoliation. Yield reductions can be significant.

SLWF is an area-wide cross commodity problem. In addition to being a serious pest of cotton, SLWF is also a major pest of vegetables especially during the fall. It is important that all of agriculture address and manage

SLWF. When all parties use sound SLWF management programs all will benefit. Following the general guidelines below, especially on a community and state-wide basis, should result in better management of SLWF area-wide.

SLWF Management Guidelines

- Destroy SLWF host crops immediately after harvest; this includes vegetable and melon crops in the spring and cotton (timely defoliation and harvest) and other crops in the fall.
- Scout cotton on a regular basis for SLWF adults and immatures. Routine sampling is required to identify the rate of SLWF population increase.
- The presence of SLWF should influence the decision to treat other insect pests and insecticide selection.
- Conserve beneficial insects; do not apply insecticides for any pests unless thresholds are exceeded.
- Minimize or avoid insecticides such as organophosphates which are prone to flare SLWF when present.

If thresholds for SLWF are exceeded timely intervention with appropriate SLWF insecticides is a must. The goal of SLWF management with insecticides is to initiate control measures just prior to the period of most rapid pest population development. It is critically important that initial insecticide applications are well timed. If you are late with the initial application control will be very difficult and expensive in the long run. It is nearly impossible to regain control once the population reaches outbreak proportions.

All efforts should be made to minimize the risk of SLWF outbreaks and reduce the need to treat SLWF with insecticide. It is important to understand risk factors associated with SLWF in cotton. Although some risk factors cannot be controlled by growers, there are a few which can be incorporated into a production system. Below are several factors which influence the risk of SLWF in cotton:

Factors Affecting SLWF Risk

Winter Weather: SLWF can reproduce on over 600 plant species. SLWF survive the winter months on both cultivated and wild host plants. Mild winters favor survival of SLWF. Freezing temperatures which kill host plants infested with immature SLWF effectively kills individual nymphs on those plants. Higher survival during winter months leads to higher populations in the spring and the opportunity for populations to rapidly build to damaging levels.

Variety Selection: hairy leaf cottons are more susceptible to SLWF compared with smooth leaf cottons. There appears to be a direct correlation of SLWF infestations based on the degree of hairiness. Risk of SLWF is greatest on hairy varieties > light hairy > semi-smooth > smooth varieties. Plant smooth leaf varieties to lower risk of SLWF, especially if other risk factors such as planting date or proximity to SLWF crops are high.

Planting Date: the risk of SLWF problems increases as planting dates are delayed. SLWF complete a generation in about 2 weeks during summer months and populations can increase rapidly. The impact of SLWF on yield is dependent on the growth stage of cotton when SLWF infest the crop. SLWF stress the crop and potential yield loss is greater when infestations appear during squaring or early bloom compared with late bloom. The duration of control required for SLWF is also dependent upon planting date. April and early May planted cotton is at lower risk for SLWF problems compared with late May and June planted cotton.

Location (proximity of SLWF infested crops): crops produced can be viewed as sources and sinks for SLWF populations. What are the likely sources of SLWF which will infest cotton? Spring vegetable and melon crops are a source of SLWF infesting cotton. In the fall cotton is a source of SLWF infesting fall vegetables. The nearness of cotton to a SLWF infested field increases the risk of SLWF. This is likely why we have historically observed SLWF in localized geographic areas.

Beneficial Insects: conserve beneficial insects, only use insecticides for other pests when thresholds are exceeded. The presence of a few SLWF in cotton should get your attention. In general, if we observe SLWF in cotton before the end of July we have potential problems.

In-Season Weather: hot and dry conditions favor SLWF development, survival, and population buildup. Thunderstorms and extended rainfall events such as tropical systems negatively impact SLWF populations on an area-wide basis.

Use IPM: scout your cotton for all insect pest on a regular basis. Use thresholds and only apply insecticides when thresholds are exceeded. When thresholds are exceeded, especially for SLWF, intervene with the most appropriate insecticide in a very timely manner. Incorporate cultural controls for other pests with the objective of minimizing total insecticide inputs and conserving beneficial insects.

Irrigation: dryland (drought stressed) cotton is at higher risk for SLWF compared with irrigated (no drought stress) cotton. We have observed for several years that SLWF infestations are more severe in dry corners of pivot irrigated fields.

Scouting SLWF is a must: SLWF adults and immatures will be found on the underside of leaves. SLWF populations in cotton are best estimated by examining the 5th main stem leaf below the terminal. Main stem leaves are attached directly to the main stem by the leaf petiole. The top or first main stem leaf below the terminal is defined as the uppermost leaf which is 1 in. or greater in diameter. Adult and immature SLWF should be counted on the 5th main stem leaf below the terminal. However there are some exceptions, in rapidly growing cotton (pre-bloom) it may be necessary to examine the 6th or 7th leaf below the terminal for immatures. Our goal is to detect the presence of developing immatures. It takes time for eggs to hatch and the immatures to develop to a size which we can see. Use of a hand lens will aid in scouting. Conversely on cotton which has cut out and vegetative growth has slowed, leaves above the 5th leaf may be more appropriate sampling locations. Again our objective is to quantify developing immatures. Steps for efficient Sampling of whiteflies are below:

Scouting SLWF in Cotton

- Familiarize yourself with the general location of the 5th main stem leaf below the terminal in each field scouted.
- Select plants at random at least 25 steps into the field and at least 10 steps apart, being careful not to disturb plants you plan to sample.
- Turn the 5th leaf over slowly by its tip or petiole and count the leaf as infested with adults if three or more adults are observed. Estimating adults will allow us to determine migration rates of SLWF infesting cotton.
- Detach the 5th leaf from the main stem (if it fails to snap off easily you may be sampling a leaf that is too high on the plant).
- Examine the bottom of the leaf for the presence of SLWF immatures. Count the leaf as infested if 5 or immatures are observed. A hand lens will aid in observing immatures.
- Sample at least 30 plants per field.
- Calculate the percentage of leaves infested with immatures. Treatment is recommended if 50 percent of the sampled leaves are infested with immatures.
- Calculate the percentage of leaves infested with adults. This is beneficial when tracking buildup and migration of SLWF into fields.

Insecticides used for control of SLWF must be applied on a timely basis. Thresholds are designed so that timely application of insecticides can be applied just prior to the period of most rapid population development. Immature populations can go from threshold levels to very high populations in a week. Again, be timely with insecticide applications when thresholds are exceeded. If you are late with the initial insecticide application control will be difficult and expensive in the long run.

The insect growth regulators (IGRs) Knack and Courier have long residual activity and minimal impact on beneficial insects. In general, the IGRs are slow acting but perform very well when applied on a timely basis. Conservation of beneficials is an important part of the IGR program. Knack is active on mature nymphs and eggs, SLWF adults exposed to Knack will lay sterile eggs. Courier is active on nymphs only. Neither IGR will directly control adults. Do not add bifenthrin to IGR sprays for SLWF, bifenthrin does not control adult SLWF anymore.

Assail, Sivanto, PQZ, and Venom are active on all stages (immatures and adults). Control of adults is inconsistent (Sivanto and PQZ are the only insecticides which control adults) due in part to re-infestation following application when populations are high. Our goal is to manage infield reproduction (i.e., control of immatures).

Invariably applications of insecticide for SLWF control will be late on some fields. In these situations, application of an insecticide which is active on all stages (Assail or Sivanto) is preferred as the initial treatment. Use of these insecticides which have activity on all life stages have quicker effects on SLWF populations compared with the IGRs. An IGR can be applied as a follow up spray to extend residual once the population is under control.

Below are two additional publications on SLWF management:

UGA Extension publication C 1141, *Cross-Commodity Management of Silverleaf Whitefly in Georgia*:

https://extension.uga.edu/publications/detail.html?number=C1141

UGA Extension publication C 1184, *Sampling and Managing Whiteflies in Georgia Cotton*:

https://extension.uga.edu/publications/detail.html?number=C1184

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.

The table here lists 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.**

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)

Boll Weevil Eradication Program (BWEP)

The BWEP is in the containment phase. Activities include reduced trapping but active spraying would occur in areas if boll weevils were detected. Boll weevils are the responsibility of the program, so growers with a suspected boll weevil should notify their local BWEP field supervisor or County Agent. 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 re-infestation. 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 re-infestations 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.

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 Strafer Max 70 WP	4A	 1.5–2.5 oz 0.6–1.3 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.
	afidopyropen Sefina 0.42	9D	 3 oz	0.0098	12 H/ 7D	
	dicrotophos Bidrin 8 Dicromax 8	1B	 4–8 oz 4–8 oz	0.25–0.5	3 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	
	sulfoxaflor Transform 50 WG	4C	 0.75–1.0 oz	0.023–0.031	24 H/ 14 D	
	thiamethoxam Centric 40 WG	4A	 1.25–2.0 oz	0.031–0.05	12 H/ 21 D	
Beet Armyworm	*diflubenzuron* Dimilin 2L	15	 4–8 oz	0.0625–0.125	12 H/ 14 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.
	indoxacarb Steward 1.25EC	22	 9.2–11.3 oz	0.09–0.11	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	
	chlorantraniliprole Vantacor 5SC	28	 1.2–2.5 oz	0.047–0.098	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 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.
	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	
	spinetoram Radiant 1 SC	5	 4.25–8 oz	0.0332–0.0625	4 H/ 28 D	
	chlorantraniliprole Vantacor 5SC	28	 1.2–2.5 oz	0.077–0.098	4 H/ 21 D	
	spinosad Blackhawk	5	 2.4–3.2 oz	0.054–0.072	4 H/ 28 D	

PEST	INSECTICIDE	MOA	FORMULATION PER ACRE	LBS. ACTIVE PER ACRE	REI/PHI (Hours or Days)	REMARKS
Bollworm/ Tobacco Budworm (*continued*)	PYRETHROIDS					Tobacco budworm is resistant to pyrethroid insecticides. Pyrethroids should not be used for control of tobacco budworm. Performance of pyrethroids used for corn earworm management may vary due to insecticide resistance.
	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	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 Declare 1.25	3A	1.28–2.05 oz	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	24 H/ 21 D	
	zeta-cypermethrin Mustang Max 0.8	3A	2.64–3.6 oz	0.0165–0.0225	12 H/ 14 D	
Cutworm (seedling cotton)	*acephate* Orthene 97 Acephate 97	1B	0.75 lb 0.75 lb	0.72	24 H/ 21 D	Apply when stand is threatened. Spot treatment is often adequate.
	chlorantraniliprole Vantacor 5SC	28	1.2–2.5 oz	0.047–0.098	4 H/ 21 D	
	pyrethroids	3A	See Remarks			Pyrethroids provide good control of cutworms at low rates. See insecticide label for use rate.

PEST	INSECTICIDE	MOA	FORMULATION PER ACRE	LBS. ACTIVE PER ACRE	REI/PHI (Hours or Days)	REMARKS
Fall Armyworm	*chlorantraniliprole* Vantacor 5SC	28	1.2–2.5 oz	0.047–0.098	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	
	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	
	pyrethroids	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	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 bugs/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	3 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	
	sulfoxaflor Transform 50 WG	4C	1.5–2.25 oz	0.047–0.071	24 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	*indoxacarb* Steward 1.25EC	22	6.7–9.2 oz	0.065–0.09	12 H/ 14 D	Treatment is necessary when soybean loopers threaten to defoliate cotton with immature bolls.
	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* Abba 0.15 Abba Ultra 0.3 Agri-Mek 0.7SC	6	8–16 oz 4–8 oz 1.75–3.5 oz	0.009–0.018	12 H/ 20 D	Apply when 50% of plants are symptomatic and populations are increasing. Spot treatment may be adequate. Thorough coverage 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.
	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	
	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 of bloom, 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	24 H/ 21 D	
	dicrotophos Bidrin 8 Dicromax 8	1B	4–8 oz 4–8 oz	0.25–0.5	3 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	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 Declare 1.25	3A	1.28–2.05 oz	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	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	1B	Commercial Seed Treatment		24 H/ 21 D	
	Orthene 97 Acephate 97		1 lb 1 lb	0.97 0.97		Apply *acephate* as a liquid into the seed furrow at planting.
	aldicarb AgLogic 15GG	1A	3.5–5 lb	0.525–0.75	48 H/ 90 D	Apply granules in the seed furrow and immediately cover seed and granules with 1" or more of soil.
	imidacloprid Admire Pro 4.6	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.
	imidacloprid Gaucho 600	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.
	thiamethoxam Cruiser	4A	Commercial Seed Treatment		12 H/ –	
Thrips (seedling cotton), Foliar Spray	*acephate* Orthene 97 *Acephate* 97	1B	3 oz 3 oz	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	6 H/ 30 D	
	dimethoate Dimethoate 4	1B	0.25–0.5 pt	0.125–0.25	48 H/ 14 D	

PEST	INSECTICIDE	MOA	FORMULATION PER ACRE	LBS. ACTIVE PER ACRE	REI/PHI (Hours or Days)	REMARKS
Whitefly (silverleaf)	*acetamiprid* Assail 30 SG Strafer Max 70 WP	4A	 4–5.3 oz 1.7–2.3 oz	0.075–0.1	12 H/ 28 D	Apply when 50% 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	4 H/ 14 D	
	pyrifluquinazon PQZ 1.87	9B	 2.4–3.2 oz	0.035–0.047	12 H/ 7 D	
	pyriproxyfen Knack 0.86	7C	8 oz 5 oz fb 5 oz	0.05375 0.033 fb 0.033	12 H/ 28 D	Split application in vegetative cotton; 5 oz followed by 5 oz (see 24(c) Special Local Need label.)
	spiromesifin Oberon 2	23	 8–16 oz	0.125–0.25	12 H/ 30 D	
	buprofezin Courier 3.6SC	16	 9–12.5 oz	0.25–0.35	12 H/ 14 D	

PREMIXED OR CO-PACKAGED INSECTICIDE PRODUCTS:

Products listed below are available as premixes or co-packages of 2 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. Labeled rates are listed with product names. However, see label for specific rates for target pests.

bifenthrin, *acetamiprid* (Argyle: 6–9 oz) *bifenthrin*, *avermectin* B1 (Athena: 7–17 oz) *bifenthrin*, *imidacloprid* (Brigadier: 3.8–7.7 oz) *bifenthrin*, *chlorantraniliprole* (Elevest: 5.6–9.6 ozs) *dicrotophos*, *bifenthrin* (Bidrin XP II: 8–12.8 oz) *fluopyram*, *imidacloprid* (Velum Total: 14–18 oz) *imidacloprid*, *cyfluthrin* (Leverage: 2.8–3.2 oz)	*lambda-cyhalothrin*, *chlorantraniliprole* (Besiege: 5–12.5 oz) *lambda-cyhalothrin*, *thiamethoxam* (Endigo: 4.5–6 oz) *methoxyfenozide*, *spinetoram* (Intrepid Edge: 4–8 oz) *novaluron*, *acetamiprid* (Cormoran 6–12 oz) *spinosad*, *gamma-cyhalothrin* (Consero: See label) *zeta-cypermethrin*, *bifenthrin* (Hero: 3.6–10.3 oz)

INSECT PEST RESPONSE TO INSECTICIDES USED IN COTTON

INSECTICIDE	SOUTHERN GREEN STINK BUG	BROWN STINK BUG	CORN EARWORM	TOBACCO BUDWORM[1]	FALL ARMYWORM	BEET ARMYWORM	SOYBEAN LOOPER	PLANT BUGS	APHIDS	SPIDER MITES	SILVERLEAF WHITEFLY	CUTWORMS	THRIPS	PREDATORS[2]	PARASITES[2]	CHEMICAL CLASS (MOA)	REI (Hours)[3]
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
aldicarb AgLogic 15GG	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	1A	48
alpha-cypermethrin Fastac 0.83	2	4	3	3	4	5	4	3	4	5	5	2	4	H	M	3A	12
beta-cyfluthrin Baythroid XL 1	1	3	3	3	3	5	4	3	4	5	5	2	4	H	M	3A	12
bifenthrin Brigade 2, Discipline 2, Fanfare 2	1	2	3	3	3	5	4	3	3	3	4	2	4	H	M	3A	12
buprofezin Courier 40 SC	—	—	—	—	—	—	—	—	—	—	1	—	—	E	E	16	12
chlorantraniliprole Vantacor 5SC	5	5	1	1	2	1	2	5	5	5	4	4	5	E	E	28	4
cypermethrin Up-Cyde 2.5EC	2	4	3	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	3 days

Efficacy Ratings: 1—Very Effective; 5—Not Effective 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 compari- son purposes.

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

INSECT PEST RESPONSE TO INSECTICIDES USED IN COTTON (*continued*)

INSECTICIDE	SOUTHERN GREEN STINK BUG	BROWN STINK BUG	CORN EARWORM	TOBACCO BUDWORM[1]	FALL ARMYWORM	BEET ARMYWORM	SOYBEAN LOOPER	PLANT BUGS	APHIDS	SPIDER MITES	SILVERLEAF WHITEFLY	CUTWORMS	THRIPS	PREDATORS[2]	PARASITES[2]	CHEMICAL CLASS (MOA)	REI (Hours)[3]
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
esfenvalerate Asana XL 0.66	2	4	3	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	3	1	5	5	5	3	E	E	9C	12
gamma-cyhalothrin Declare 1.25	1	3	3	3	3	5	4	3	4	5	5	2	4	H	M	3A	24
imidacloprid Admire Pro 4.6	4	4	5	5	5	5	5	3	3	5	4	5	3	M	M	4A	12
indoxacarb Steward 1.25	4	4	2	1	2	1	1	4	5	5	5	4	5	M	E	22A	12
lambda-cyhalothrin Warrior II Z 2.08, Silencer 1	1	3	3	3	3	5	4	3	4	5	5	2	4	H	M	3A	24

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INSECT PEST RESPONSE TO INSECTICIDES USED IN COTTON (*continued*)

INSECTICIDE	SOUTHERN GREEN STINK BUG	BROWN STINK BUG	CORN EARWORM	TOBACCO BUDWORM[1]	FALL ARMYWORM	BEET ARMYWORM	SOYBEAN LOOPER	PLANT BUGS	APHIDS	SPIDER MITES	SILVERLEAF WHITEFLY	CUTWORMS	THRIPS	PREDATORS[2]	PARASITES[2]	CHEMICAL CLASS (MOA)	REI (Hours)[3]
methomyl Lannate LV 2.4	4	4	3	3	3	4	3	4	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	3	5	5	5	5	3	M	M	1A	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
sulfoxaflor Transform 50 WG	4	4	—	—	—	—	—	1	1	—	4	—	—	E	E	4C	24
thiamethoxam Centric 40 WG	3	4	5	5	5	5	5	2	2	5	3	5	3	M	M	4A	12
zeta-cypermetherin Mustang Max 0.8	1	3	3	3	3	5	4	3	4	5	5	2	4	H	M	3A	12

Efficacy Ratings: 1—Very Effective; 5—Not Effective 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 compari- son purposes.

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3. Read and follow label directions.

COTTON DISEASE AND NEMATODE MANAGEMENT

SECTION 1. UPDATE FOR THE 2024 GROWING SEASON:

Note: At the time submission of this chapter, information on disease and nematode resistance in cotton varieties new for 2024 is not fully available. Growers should continue to seek information for 2024 varieties from UGA Extension and from cottonseed dealers.

If you read no further, please consider the following because you will often have only ONE chance:

1. The winter of 2023-2024 is predicted to be an "El Niño" ENSO Phase. This will be our first in "El Niño in four years; these winters are characterized by climate that is both cooler and wetter than "normal". Increased rainfall during the winter helps to hasten decay of crop debris that harbors fungal pathogens; freezing weather with cold soils helps to reduce activity of nematodes and also may kill plants upon which they can feed.
2. It is quite possible that the planting season, if cooler and wetter, will be more favorable for seedling diseases caused by fungi, especially *Rhizoctonia* and *Pythium*. Cotton growers will have one chance in 2024 to manage seedling diseases effectively. Once the furrow is closed, the die for management options is cast. UGA Extension recommends carefully considering if additional seed treatments or in-furrow fungicides are needed based upon factors to include crop rotation, tillage, and environmental conditions, especially soil temperature and soil moisture. To avoid increased risk to loss to seedling disease, cotton should not be planted until soils can be expected to remain above 65°F. Where risk to seedling disease exists (cooler and wetter soils), growers are encouraged to wait until conditions improve and to consider using an infurrow fungicide to compliment fungicide seed treatments. Azoxystrobin is an effective fungicide against *Rhizoctonia*.
3. Cotton growers will have one "best" chance in 2024 to effectively manage nematodes. Once the furrow is closed, the opportunity to plant a nematode-resistant variety or to apply a nematicide, is over, though supplemental applications of Vydate-CLV can be made. Decisions for nematode management are best based upon field history of problems with nematodes and soil samples collected soon after harvest for nematode assessment. Growers must not miss this opportunity.
4. Where root-knot and/or reniform nematodes are a problem, grower will have opportunity to plant resistant varieties from Phytogen, Deltapine, Dynagro, and Stoneville (root-knot only) in 2024. Results from trials conducted in 2023 (to be presented at grower meetings in 2024) will further document the advantages root-knot and reniform resistant planted in nematode-infested fields.
5. Cotton growers will have one chance to manage bacterial blight in 2024; the only tool to manage bacterial blight is to plant a bacterial blight-resistant variety.
6. Results from an increasing number of fungicide trials continue to demonstrate the benefit of protecting cotton from areolate mildew and target spot with fungicides. All cotton growers should be prepared to use fungicides to protect against areolate mildew and/or target spot in 2024. NOTE: The fungicide Azoxystrobin is no longer recommended for management of areolate mildew because of concerns over fungicide resistance.
7. Boll rot continues cause significant yield loss in some fields across Georgia. Efforts throughout the season to avoid rank growth to occur can help to reduce risk to this complex of diseases.

Reducing the impact of diseases and nematodes in your cotton crop

The importance of diseases and nematodes in cotton production may be overlooked as the cotton plant is affected by fewer diseases than are other crops grown in Georgia and symptoms caused by nematodes can be easily attributed to other causes. Best management of diseases and nematodes in any crop should begin prior to onset of symptoms. Once symptoms appear, it is much more difficult, and sometimes impossible, to prevent yields losses from occurring.

Growers can effectively reduce the impact of diseases and nematodes on their cotton crop by making sound management decisions. These include:

1. use of crop rotation to minimize problems with nematodes and soilborne diseases
2. choice of planting date where temperature and soil moisture supports rapid germination and vigorous growth
3. management of fertility and plant development to avoid excessive and rank growth
4. choice of cotton variety, especially selection of disease and/or nematode resistant varieties
5. use of seed treatments and in-furrow fungicide applications for management of seedling diseases
6. use of appropriate nematicides
7. timely application of appropriate fungicides for management of target spot and areolate mildew
8. scouting of fields for early detection of disease and nematode problems
9. collection of soil samples for detection of plant-parasitic nematodes soon after harvest

Although difficult for some growers, good crop rotation with crops that are non-host for major plant-parasitic nematodes (especially southern root-knot and reniform nematodes) and pathogens (for example *Rhizoctonia solani*) remains one of the most effective means of reducing losses in cotton. In the 2024 field season, growers will be able to select cotton varieties with resistance to southern root-knot nematodes, reniform nematodes, and bacterial blight; though a single variety may not be resistant to all of these pests. Growers will also have an expanding arsenal of fungicides to choose from for management of target spot.

From last season: The 2023 season proved once again the importance of protecting the cotton crop against nematode and the judicious use of fungicides to protect against areolate mildew.

Listed here are some of the most important disease and nematode considerations for producing cotton in 2024. Each topic will be discussed in greater detail later in the chapter.

Areolate mildew (also known as Ramularia leaf spot; caused by the fungus *Ramulariopsis gossypii*/*Ramularia areola*) is identified by the presence of a powdery growth of white-to-gray spores on the underside of the cotton leaves. Areolate mildew typically occurs later in the season and is favored by wet and humid conditions. Historically, losses to areolate mildew were uncommon in Georgia; however if the disease occurs early enough in the season, subsequent premature defoliation will impact yield. The fungus overwinters in infected crop debris from the previous season. Information is not available on varieties that may be more-resistant. Fungicides are effective in the management of areolate mildew and may increase yields by as much as 200 lb lint/a. However, fungicides are not always economically justified and they must be applied before the disease becomes severe and widespread in a field. Areolate mildew is most often observed in the southeastern production regions of Georgia, east of I-75. However, the disease has been much more widespread since 2017. In 2024 growers may apply fungicides (for example, Priaxor, Revytek, and Miravis Top) to slow the spread of the disease. Research trials have confirmed that significant yield increases can be associated with the judicious use of specific fungicides in the presence of areolate mildew. Growers are cautioned that Quadris, Headline, and generic azoxystrobin products may no longer be as effective against areolate mildew.

Cotton leafroll dwarf virus (CLRDV) continued to be of minimal importance in 2023 on cotton production in Georgia. First reported in Alabama in 2017, then confirmed in Georgia in 2018, the full impact of this viral disease remains unclear. From the "First report of Cotton leafroll dwarf virus infecting Cotton in Georgia, USA" which was submitted for publication in the scientific literature, it is stated that, "During the 2018 growing season, cotton plants in several fields in Georgia were observed with foliar distortion, mosaic, cupping, curling, and downward rolling of leaves, dark greening, and shortened internodes, in the upper portion of the plants resembling that of Cotton blue disease caused by Cotton leafroll dwarf virus (CLRDV) (Family Luteoviridae, Genus Polerovirus). CLRDV is phloem-limited single-stranded (+) RNA genome virus transmitted by aphids in a persistent, circulative and non-propagative manner. Symptomatic leaves and petioles were collected from different fields at the University of Georgia-experimental farms in Tifton and other commercial cotton fields." Presence of the virus has been confirmed by Dr. Sudeep Bag at the University of Georgia. The virus is spread by cotton aphids; however efforts to manage the aphids have not affected the development of CLRDV.

Symptoms of CLRDV:
(as described "Report of A Research Review and Planning Meeting on Cotton Leafroll Dwarf Virus Orange Beach, Alabama – October 8, 2019" and drafted by R Kemerait, A. Hagan, T. Allen, and R. Nichols)

Cotton plants testing positive exhibit one or more of the symptoms described below. Symptom expression appears to differ by cultivar and by time of infection and subsequent disease progression.

1. In the early season, seedlings and young plants often show significant reddening, stunting, and downward cupping of the leaves. Additional symptoms include yellowing around the leaf margins and rugosity along the veins of the youngest leaves. In severe cases, death of the seedling/young plant may occur. With good growing conditions, some of these plants determined to contain the virus show signs of recovery following the initial symptoms; however, they will likely remain stunted and set few fruit.
2. Symptoms observed in mid-season progress to more reddening and cupping of the foliage, beginning first in the uppermost parts of the canopy. Stems and petioles may be red around their complete circumference and red veins may be observed in the leaves. New leaves are often crinkled or rugose in appearance. In extreme cases, large portions of the canopy are affected, and the foliage develops yellow, bronze, or red. Whereas extreme reddening has been observed in Georgia, such coloration has not been observed in Mississippi.

   Additional symptom expression is likely to include significant compression of internodes near the terminal and little-to-no fruit production on certain symptomatic plants. Flowers on symptomatic plants may be devoid of pollen and have misshapen or elongated flower parts (e.g., elongated stigma with stamens wrapped around the stigma in a whorl pattern). With good growing conditions, symptomatic plants may recover their green color; however, they may remain stunted and suffer fruit loss.
3. Symptoms associated with CLRDV late in the season include a) compression of internodes, b) excessive elongation of vegetative growth in the upper main stem that produces a "whip" appearance, c) excessive, compact flowering, and in most cases flower/square abortion in the upper canopy, d) excessive vegetative branching from the bottom of the plant, e) stems that appear thicker than normal, f) misshaped (parrot-beaked) and abnormal boll size and shape, g) dark green coloration of the entire plant, sometimes with a bluish to purplish cast h) leaf tissue that feels thicker than normal (in some cases rubbery), i) reduced fruit set on severely infected plants, and j) excessive square production followed by rapid square abortion.
4. Symptoms associated with CLRDV on regrowth following defoliation include visible crinkling of the leaves, single-lobed or three-lobed leaves and, at times, reddening of petioles.

Diagnosing the presence of CLRDV-infected plants in the field can be difficult. There are a number of reasons for this including:

1. Some symptoms associated with CLRDV can be the result of other causal factors. For example, several forms of stress and certain nutrient deficiencies can cause reddening of the foliage. Seedling diseases and Fusarium wilt can also produce symptoms similar to those of CLRDV early in the season.
2. Symptoms associated with CLRDV can be variable and may be associated or exacerbated with the stress.
3. Symptoms of CLRDV can diminish over time. Plants appear to recover.
4. Symptoms associated with CLRDV appear to differ by cultivar. Some varieties present mild symptoms (e.g., leaf rolling, limited node stacking, no elongated terminal growth); Others present severe symptoms (e.g., leaf rolling, node stacking, enhanced terminal elongation, extreme vegetative branching from the bottom of the plant, a high rate of flower/square production followed by abortion).

For 2023, our recommendations are to grow cotton as we have been successful in the past and to avoid late-plantings where possible. Early-season symptoms of CLRDV have been more pronounced in DG 3615 B3XF and DG 3799 B3XF than in other varieties; however, when the incidence of disease in a field is low, the impact on yield is likely small.

Bacterial blight can cause significant yield loss and has been of concern to cotton growers since 2015. Because many of our newer cotton varieties have resistance to bacterial blight, the impact of this disease has decreased steadily in Georgia over the past few seasons. Bacterial bight has generally not been a problem since 2016, but without diligence from the cottonseed industry and from growers, it could become a problem again. The single most important and effective way to manage bacterial blight is to plant a more-resistant variety and to avoid planting susceptible varieties. However, growers must understand that despite susceptibility of some root-knot-nematode-resistant varieties to bacterial blight, the threat from root-knot nematodes is much higher in some fields than is risk to bacterial blight. Good news for growers now is that there are cotton varieties that are resistant to both the southern root-knot nematode AND to bacterial blight. Soon there will be varieties that are not only resistant to bacterial blight and southern root-knot nematodes, but to reniform nematode as well.

Varieties reported to have resistance to bacterial blight:
(additional varieties are likely available in 2024)

PHY 332 W3FE (high resistance to southern root-knot nematodes and resistance to reniform nematodes)
PHY 350 W3FE (also high resistance to southern root-knot nematodes)
PHY 360 W3FE (also with resistance to southern root-knot nematodes)
PHY 400 W3FE (also with resistance to southern root-knot nematodes)
PHY 411 W3FE (high resistance to southern root-knot nematodes and resistance to reniform nematodes)
PHY 415 W3FE (also high resistance to southern root-knot nematodes)
PHY 430 W3FE
PHY 440 W3FE (also high resistance to southern root-knot nematodes)
PHY 443 W3FE (high resistance to southern root-knot nematodes and resistance to reniform nematodes)
PHY 480 W3FE (also high resistance to southern root-knot nematodes)
PHY 500 W3FE (also with resistance to southern root-knot nematodes)
PHY 530 W3FE (also high resistance to southern root-knot nematodes)
PHY 545 W3FE (also high resistance to southern root-knot nematodes)
PHY 580 W3FE (also high resistance to southern root-knot nematodes)

NG 3299 B3XF
NG 4335 B3TXF
NG 4936 B2XF
NG 5711 B3XF

DP 1646 B2XF – Moderately resistant
DP 1840 B3XF
DP 2012 B3XF
DP 2020 B3XF
DP 2038 B3XF
DP 2131 B3TXF – Moderately resistant
DP 2317 B3TXF
DP 2349NR B3XF (also with resistance to southern root-knot nematodes)

DG 3528 B3XF
DG 3615 B3XF
DG 3799 B3XF

AR 9831 B3XF
AR 9383 B3TXF

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

Losses to bacterial blight have occurred in some fields. However, in other fields where bacterial blight was found the damage was "cosmetic" with very little, if any, loss. 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.

Plant-parasitic Nematodes

Nematodes continue to be a significant problem for many cotton growers in Georgia.

Management of southern root-knot nematodes: For 2024, consider planting resistant varieties, to include DP 2141NR B3XF (also reniform nematode resistance), DP 2349NR B3XF, PHY 332 W3FE (also reniform nematode resistance), PHY 350 W3FE, PHY 360 W3FE, PHY 400 W3FE, PHY 411 W3FE (also reniform nematode resistance), PHY 415 W3FE, PHY 440 W3FE, PHY 443 W3FE (also reniform nematode resistance), PHY 480 W3FE, PHY 500 W3FE, PHY 530 W3FE, PHY 580 W3FE, and DG 3644 B3XF (also reniform nematode resistance).

Additional nematode-resistant varieties may be available in 2024.

Attention should be exercised again this year in variety selection based upon need for root-knot nematode resistance versus the importance of bacterial blight. For example, DP 2141NR B3XF has excellent resistance to southern root-knot nematodes, but is susceptible to bacterial blight.

Recommendations for varieties such as DP 2141NR B3XF and DG 3644 B3XF 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 2015-2023? 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 root-knot nematode varieties should be considered. If you had significant impact from bacterial blight in 2015-2023, 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 will want to select a variety with bacterial blight resistance and manage nematodes with nematicides or plant varieties that are resistant to both.

Management of nematodes with Telone II: Telone II is a very effective tool for management of plant-parasitic nematodes. Fumigation with Telone II (3 gal/a) using "risk management of zones" and "site specific" applications to maximize yields and minimize cost are important advances in management of nematodes affecting cotton. **NOTE:** The supply of Telone II is likely to be tight in 2024. Growers who would like to use Telone II in 2024 should contact their supplier early to make plans for obtaining needed product.

Management of nematodes: In 2024, cotton growers in Georgia can choose from several seed treatment nematicides to include Avicta Complete Cotton from Syngenta, BioST Nematicide 100 from Albaugh, and COPeO Prime from BASF. Growers also can select from Velum (fluopyram alone) and AgLogic15G (aldicarb) 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. Growers will have access to oxamyl formulated as Vydate-CLV from CORTEVA and ReTurn XL from AMVAC.

Fusarium wilt: This disease causes significant losses in some fields every year; management options include crop rotation and management of nematodes. If southern root-knot nematodes are associated with the Fusarium wilt, then planting root-knot nematode resistant varieties could help manage Fusarium wilt. However, it seems that many fields affected by Fusarium wilt are often infested with the sting nematodes. 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 disease and nematicides are the only option. Fields affected by Fusarium wilt do respond well to fumigation with Telone II and sometimes to treatment with Velum or AgLogic.

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-in. 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.

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 premium seed treatment fungicides 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 include 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.

Special Notes 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 healthy 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, Miravis Top, and Twinline) can reduce premature defoliation resulting from target spot, but 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 verify the best timing for application of fungicides by scouting fields before disease occurs.) Use of Priaxor or Miravis Top 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 resistance. 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 Revytek, Priaxor, Elatus, Miravis Top, Headline, Quadris or Twinline. 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 2 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.**

Managing Target Spot and Areolate Mildew

Target spot (*Corynespora cassiicola*) and areolate mildew (*Ramulariopsis gossyppii*) are the two most important leaf diseases affecting cotton in Georgia later in the growing season. For both target spot and areolate mildew, judicious use of fungicides not only protects the crop, but can increase yield profitability as well. Another disease, Stemphylium leaf spot, is often even more common than either target spot or areolae mildew in Georgia's cotton crop. However, as Stemphylium leaf spot results from a deficiency of potassium within the plant, to date use fungicides has not proven to be an effective management strategy.

The two fungicides that have performed "best" against target spot have been Priaxor and Miravis Top. Close behind this pair has been Headline. Azoxystrobin is a fair-to-good fungicide for control of target spot but is no longer recommended for control of areolate mildew.

Amistar Top, a combination of azoxystrobin and difenconazole, is another fungicide that could be considered when Priaxor, Miravis Top, and Headline are in short supply. The use rate for Amistar Top is 8-11.6 fl oz/a.

Growers should consider protecting their cotton crop from target spot between the 1st and 6th weeks of bloom IF the disease is present, or is likely to develop, and conditions are favorable for development and spread, and IF the crop has good yield potential. Judicious use of fungicides can protect as much as 250 lb of lint where target spot is problematic. Where the crop is suffering from drought or poor growth from other causes, protection against target spot with a fungicide may not be warranted.

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 potassium deficiency 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 rapid 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: Areolate mildew, caused by the fungal pathogen *Ramularia areola*, has been of limited importance in Georgia and is generally confined to the southeastern region of the state, especially during periods of abundant rainfall. It has become more widespread since 2017 and use of fungicides to protect against this disease can be effective in protecting yield, if the disease occurs early enough in the season. 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 2024: 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, survival 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 losses 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 infected debris and reduce inoculum surviving between seasons.

Variety Selection for Management of Bacterial Blight:

The only effective management strategy for control of bacterial blight is to plant a resistant variety. Cotton growers are ADIVSED to understand whether or not a variety is susceptible to bacterial blight before planting it. Such information is easily available through the seed dealer.

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 likely 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.)**

Areolate mildew was more widespread along the Coastal Plain of Georgia than at any other time in the past 20 years.

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 Stemphylium 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 cassiicola* (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 citri* 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, Revytek, Twinline, Elatus, Miravis Top, 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), Miravis Top (a pre-mix of Miravis and difenoconazole) and Twinline (a pre-mix of pyraclostrobin and metconazole) are fungicides that can be used to manage **target spot and areolate mildew**. 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.

Therefore, growers should consider the following:

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

In the case of target spot and areolate mildew, 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 or areolate mildew is severe. Foliar diseases are 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 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, COPeO Prime, NemaStrike, BIOst, Velum, 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

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.

Other nematicide seed treatments for cotton today include:

COPeO Prime (fluopyram + imidicloprid)

BioST Nematicide 100: Active Ingredient: Heat-killed Burkholderia spp. strain A396 and spent fermentation media

From past research: 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 Acceleron N GOOD ENOUGH for my field and, if not, what other options do I have?".

Use of Vydate C-LV (oxamyl) or ReTurn XL

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 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. ReTurn XL (active ingredient oxamyl) is a similar product to Vydate C-LV and is from AMVAC.**

Velum Total Technical Notes

Active Ingredients:	Fluopyram + Imidacloprid
Chemical class:	Pyramide + Neonicotinoid
Formulation:	Soluble concentrate contains 1.50 lb FLUOPYRAM and 2.17 lb 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

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 returned this product 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?
Gypsum formulation is 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 interstitial 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 2023- Nematode management:

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 "high 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 varieties are unlikely to see a benefit to treating the field with an additional nematicide (to include seed-treatment, Velum, 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 have greater resistance to root-knot nematode varieties than do varieties with a single resistance gene.

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 provided by nematicides.

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 widespread 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 areas 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 known 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.

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.

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.

COTTON DISEASE CONTROL

Bob Kemerait, Extension Plant Pathologist

DISEASE	CHEMICAL	MOA	RATE PER ACRE[a] (38" Row Basis)	REI/PHI (Hours/Days)	REMARKS AND PRECAUTIONS
Seedling Diseases	*azoxystrobin* Quadris 2.08SC	11	5.5–11 fl oz	4 H/ 45 D	Liquids give better coverage than granular or hopperbox treatments. Liquid fungicides should be applied in-furrow using two cone-type nozzle tips. Mount the first behind the seed-drop tube to treat the soil around seed; direct the second to treat soil as it falls into the seed furrow. Maximum rate is 27 fl oz/a/season.
	prothioconazole Proline	3	5.7–7.1 fl oz		
	ADDITIONAL SEED TREATMENTS				
	azoxystrobin+fludioxonil+mefenoxam Dynasty CST		3.1–3.95 fl oz/cwt	24 H/ —	**NOTE:** These seed treatments are in addition to fungicide treatments that are already applied to the seed by the supplier.
	chloroneb + metalaxyl Delta Coat		8.75–11.85 oz/cwt		
	Kodiak FL		0.5 fl oz/cwt		
	Kodiak HB (biological)		4 oz/cwt		
	System 3 (biological)		12 oz/cwt		
	trifloxystrobin + metalaxyl Trilex 2000		2 fl oz/cwt		
	trifloxystrobin + metalaxyl + triademinol Trilex Advanced		1.6 fl oz/cwt		

a. In-furrow fungicide rates are presented on a per acre basis for cotton planted on 38" rows. To convert these rates to cotton planted on 36" rows, multiply the 38" rate by 1.05. To convert the rates to cotton planted on 40" rows, multiply the 38" rate by 0.95. To convert the rates from a per acre basis to a rate per 1000 feet of row, divide the 36" rate by 14.42, divide the 38" rate by 13.76, and divide the 40" rate by 13.07.

b. Apply all liquids in 5–10 gal of water/a.

COTTON NEMATODE CONTROL

Bob Kemerait, Extension Plant Pathologist

NEMATICIDE TREATMENT	RATE/aCRE	OZ/1000 FT OF ROW (38" row basis)	REI/PHI (Hours/Days)	REMARKS AND PRECAUTIONS
abamectin + thiamethoxam AVICTA Duo Cotton	Seed treatment		48 H/ —	
aldicarb AgLogic 15G	3.5–7 lb			Apply granules in seed furrow and immediately cover with soil by mechanical means. In the States of AL, FL, GA, and SC, if a vulnerable soil is present and the water table is less than 25 feet below ground surface, do not apply within 700 feet of a drinking water well unless it is known or reasonably believed based upon authoritative sources that such wells are either cased to 100 feet below the ground level or a minimum of 30 feet below the water table. If it is not known whether the water table is greater than 25 feet below ground surface, assume that the water table is less than 25 feet below ground surface.
aldicarb AgLogic 15G sidedress application	5 lb			**Side Dress Application**: From 3 weeks after planting through first squaring. Side dress granules in a furrow that is 6–10" to one or both sides of plant row to a depth of 2–3". Adjust applications to minimize root pruning.
AERIS Seed-Applied System	Seed treatment			AERIS Seed-Applied System is a combination of *thiodicarb* (nematode control) and *imidacloprid* (thrips control) with the option of adding the TRILEX Advanced Seed-Applied System for additional control of seedling diseases. AERIS Seed-Applied System should only be considered for use in fields with low-to-moderate populations of plant parasitic nematodes. Maximum rate of 25.6 fl oz/100 lb of seed (de-linted seed only).
derived from the bacterium, *Burkholderia rinojensis* BIOST Nematicide 100	Seed treatment			The active ingredient is 'Heat Killed' *Burkholderia rinojensis* and spent fermentation media that contains enzymes and toxins that have broad spectrum activity on nematodes and activity on soil-dwelling insects.
fluopyram COPeO Prime	Seed treatment			COPeO Prime contains *fluopyram* for the management of nematodes affecting cotton.
fluopyram Velum	5.0–6.84 fl oz		12 H/ 30D	Velum is also labeled for suppression of Fusarium wilt. Velum will replace Velum Prime as Bayers nematicide. All Velum Total uses in Georgia will switch to the new Velum product. While there may be some Velum Total still available on-farm in 2021, there should not be any Velum Total sold commercially. Note that without the imidicloprid component, Velum will not control thrips.
Telone II[1]	3 gal	30 fl oz	5 D Post Application/ —	Apply Telone II at least 7 days prior to planting by injecting 12" below final soil surface. Temik may be used at planting or as a side-dress following the use of Telone II. NOTE: Telone II is now labeled for at-plant application in Georgia for nematode control on cotton. Growers who choose to apply Telone II at plant must ensure that soil conditions are correct (see label) otherwise the at-plant fumigation may result in poor germination and plant stand.
Vydate C-LV	17 fl oz	1.24 fl oz	48 H/ 14D	Make one application between 2nd and 5th true leaf stage. Alternatively, sequential applications of Vydate C-LV may be made at 8.5–11 fl oz/a beginning at 2nd–5th leaf stage of growth followed by a second 8.5–11 fl oz/a applied 10–14 days later. Applications of Vydate C-LV typically follow use of Telone II or nematicide seed treatments. Vydate C-LV is a supplemental application. Maximum rate is 102 fl oz/a/season.
tioxazefen Acceleron Nemastrike ST				Acceleron Nemastrike ST is a seed treatment nematicide for use on cotton.

1. If Telone II is used for nematode control, you must use an additional chemical for thrips control.
2. AgLogic 15G applied at 3.5 lb/a is often recommended for insect management, but 3.5 lb/a will not provide sufficient nematode control in Georgia.

COTTON FOLIAR DISEASE CONTROL

Bob Kemerait, Extension Plant Pathologist

FUNGICIDE TREATMENT	RATE/aCRE	REI/PHI (Hours/Days)	REMARKS AND PRECAUTIONS
azoxystrobin AzoxyStar	6–9 fl oz	— 45D	
azoxystrobin Quadris	6–9 fl oz	4H/ 45D	Maximum rate is 27 fl oz/a/season.
azoxystrobin + benzobendiflupyr (solatenol) Elatus	5–7.3 fl oz	12 H/ 45D	Do not apply more than 14.6 fl oz/a per season.
azoxystrobin + difenconazole Amistar Top	8–11.6 fl oz	— 0D	Do not apply more than two sequential applications before alternating to a fungicide with a different mode of action.
difenoconazole + pydiflumetofen Miravis Top	13.6 fl oz	12H/ 45D	
flutriafol Topguard	7–14 fl oz	12 H/ 30D	
flutriafol + azoxystrobin TopGuard EQ	5–7 fl oz	12H/ 45D	
prothioconazole Proline	5.0–5.7 fl oz	12H/	Do not make more than three total applications per season.
pyraclostrobin Headline	6–12 fl oz	12 H/ 30D	
pyraclostrobin + fluxapyroxad Priaxor	4–8 fl oz	12H/ 30D	Do not apply more than 24 fl oz/a per season.
pyraclostrobin+ metconazole Twinline	7–8.5 fl oz	12 H/ 30D	Maximum rate is 26 fl oz/a/season.

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 more so 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 in. 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 in. range. Applications that are not made until cotton reaches 30 in. often do not adequately control growth. Some 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 reduce 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.

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.

Contact your local UGA County Extension Agent 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, soils with low soil water holding capacities, and the climate variability we typically experience in the Southeastern Region. Irrigation is particularly important in areas that frequently have drought in July through August and on locations with sandy textured soils. It is commonly said that in the Coastal Plains we are never more the three or four days away from a drought, and based on our major soil types in the region that is true. 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. It should be stressed that it is not necessarily about the total amount of rainfall that is received, but the frequency and distribution of that rainfall that matters when it comes to producing high levels of yield.

This is also true for irrigation, it is not necessarily about the total amount of irrigation applied, but that an ample amount is applied at the correct time. 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 capacity and water supply. The most critical period of water requirement is during the bloom and boll maturation periods. At peak bloom, the plant can require up to about 0.3 in. of water per day but, factors such as available soil moisture in the profile, soil type and atmospheric conditions can increase or lower this need. Recent UGA research indicated that timely irrigation with moderate rates during squaring (period when potential fruiting sites are developing) may also have a strong influence on yields.

There are still questions to be answered on irrigation scheduling. While many of the recent cotton production seasons have had in excess of 20 plus in. of rain there are periods of drought during each season which cause production to fall well below expectations in terms of yield and fiber quality. Careful consideration is advised during high rainfall or wet years as excessive irrigation can reduce yield potential, to in some cases below the level of the dryland crop. It is advised to implement a sound irrigation scheduling strategy during any year. Strategies may include the UGA Checkbook method, irrigation scheduling apps, and probably the most reliable and accurate means are with soil moisture sensors. The major take home point is to have at least one option of scheduling irrigation and multiple options are even better.

A 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: 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 in. 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. It is encouraged that producers follow the UGA Checkbook method developed from 2001-2016 historical average evapotranspiration data (Table 7 and Figure 18). After first bloom, producers trying for high yields are encouraged to irrigate as needed to supply the quantities of water listed in Table 8. 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 under "***Irrigation Example***."

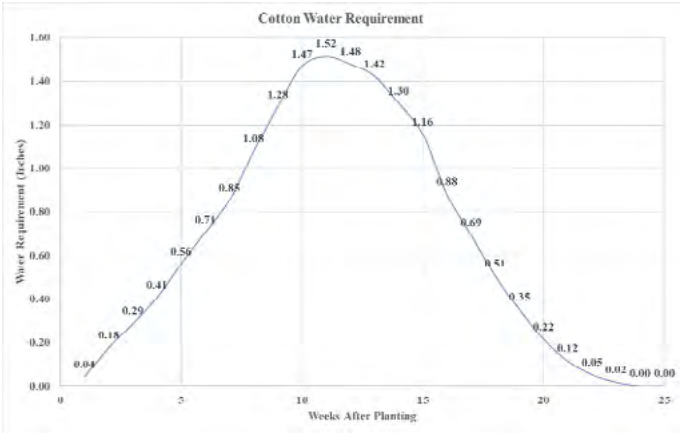


Figure 18. Weekly UGA Checkbook Cotton Irrigation for Full Season.

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. Additionally, a

Table 7. UGA Checkbook Cotton Irrigation Schedule for Full Season.

Growth Stage	Days After Planting	Weeks After Planting	Inches Per Week	Inches Per Day
Emergence	1–7	1	0.04	0.01
Emergence to First Square	8–14	2	0.18	0.03
	15–21	3	0.29	0.04
	22–28	4	0.41	0.06
	29–35	5	0.56	0.08
First Square to First Flower	36–42	6	0.71	0.10
	43–49	7	0.85	0.12
	50–56	8	1.08	0.15
First Flower to First Open Boll	57–63	9	1.28	0.18
	64–70	10	1.47	0.21
	71–77	11	1.52	0.22
	78–84	12	1.48	0.20
	85–91	13	1.42	0.20
	92–98	14	1.30	0.19
	99–105	15	1.16	0.17
	106–112	16	0.88	0.13
	113–119	17	0.69	0.10
First Open Boll to > 60% Open Bolls	120–126	18	0.51	0.07
	127–133	19	0.35	0.05
	134–140	20	0.22	0.03
	141–147	21	0.12	0.02
	148–154	22	0.05	0.01
	155–161	23	0.02	0.00
Harvest	162–168	24	0.00	0.00
	169–175	25	0.00	0.00

Table 8. Cotton Irrigation Schedule Suggested for High Yields.

Crop Stage	Inches Per Week	Inches Per 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

recent multi-year study at UGA showed no effects on yield when irrigation was terminated during cutout versus 10% open boll, however, at this time more data are needed to validate this recommendation. Common sense factors for irrigation scheduling and recommended application amounts include prevailing weather patterns and predictions, available soil moisture, and time of year. It has been shown that a field will remain at a sufficient soil moisture level to finish off the season by maintaining recommended irrigation applications up to the 10% open boll stage. In the event that a last irrigation event is required to finish the crop it is recommended to apply around 0.75-0.80 in. to provide adequate soil moisture in the profile. At this time of season when bolls are open and fiber is exposed to the environment repeated short applications of 0.30-0.50 in. usually do more harm than good.

Growers with intensely managed production programs that are already harvesting 1200-1300 lb per acre yields and are striving for 1500 lb 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 achieve high yields should consider implementing a very robust irrigation management plan, which could include the use of consultants, advanced irrigation scheduling tools that include but are not limited to soil moisture sensors, and online or smartphone app schedulers. A publication which contains more in-depth information about placement and interpretation of data on soil moisture sensors, is located here: https://cottoncultivated.cottoninc.com/research_reports/placement-and-interpretation-of-soil-moisture-sensors-for-irrigated-cotton-production-in-humid-regions/.

Irrigation Example

Step 1. The soil type of the field is a Tifton loamy sand. In Table 3, the average available water holding capacity is 1.0 in./ft. Assuming a rooting depth of 2 feet, the total available water is 2.0 in. (2 ft x 1.0 in./ft).

Step 2. If the cotton crop is determined to be during the 3rd week of bloom. From Table 2, the daily water use by the crop is 0.3 in./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, 1.0 in. of water will be required to replace the water used (2.0 in. 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 9. (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 = 1.0 in. / 0.88 = 1.14 in.

Step 5. Determine the frequency of irrigation by dividing the amount of water replaced by water use per day. For example, frequency = 1.0 / 0.3 = 3.3 days.

Step 6. In this example, it would be necessary to apply 1.14 in. 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 irrigation application amount greater than 0.75 in. results in runoff in most soil types in Georgia. This means that you will lose any additional water over 0.75 in., 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 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 1.14 in. were split into two applications of 0.57 in. 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 reach and infiltrate into the soil.

Irrigation 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 9. Examples of Available Water Holding Capacities and Infiltration Rates of Soils in the Coastal Plain of Georgia.

Soil Series	Description	Intake for Bare Soil* (inches per hour)	Available Water Holding Capacity (inches per foot)
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 10. Examples of Application Efficiency Values for Various Irrigation Systems.

Irrigation System Type	Application efficiency (%)	
	Attainable	Expected
Center pivot with impact sprinklers	85	75–85
Center pivot with spray-type sprinklers	95	75–95
Lateral move with spray-type sprinklers	95	75–95
Subsurface drip	95	70–95
Micro-spray	95	70–95
Trickle	95	75–95
Mocing big gun	75	60–75

Irrigation Scheduling

The moisture balance or “Checkbook” 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 Irrigator Pro (USDA, www.irrigatorpro.org), soil moisture sensors from companies such as Irrometer, Meter, AquaSpy, CropX, AquaCheck, etc., and the SmartIrrigation Cotton App (www.Smartirrigationapps.org) 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 and water-use efficiency levels when compared to other methods because they are providing current 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 robust 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 timing and 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.

Knowing how aggressive your cotton variety grows and how well it responds to plant growth regulators is important. Keep in mind to never control or slow plant growth with irrigation applications. Apply water according to the plant needs and available soil moisture and let the PGR do its job.

DEFOLIATION

Cotton defoliates much easier when a good boll load has been obtained and available soil nitrogen is nearly depleted by the crop. At 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 Pest Management Handbook) below for information about rates and combinations of harvest aids.

Timing of Defoliation

Timing of defoliation is critical to insure optimum yield and fiber quality. Several factors can be used to determine the proper time for harvest aid application. The first is the traditional method of counting open and unopen bolls. Defoliation should proceed when least 60 to 75 percent of bolls are open. This method focuses primarily on the "open" portion of the bolls while ignoring the "unopen" portion, which is also important. A second indicator involves slicing bolls with a sharp knife. Bolls are considered mature--and ready for harvest aid applications--when bolls cannot be sliced without "stringing" the lint. In addition, bolls are mature when the seed embryo contains only tiny folded leaves (no "jelly" within the developing seed) and the seedcoat begins to turn yellow or tan. A final method utilized to determine crop maturity is counting nodes above cracked boll (NACB). NACB is determined by counting the number of nodes separating the uppermost first position cracked boll and the uppermost 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 figure on the right shows predicted percent open bolls to NACB (60% = 4.1 NACB).

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

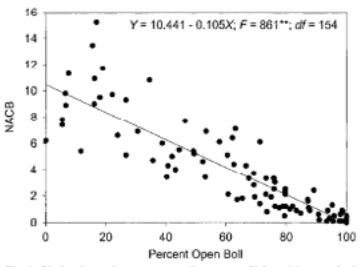


Fig. 1. Nodes from the uppermost first sympodial position cracked boll to the uppermost harvestable boll (NACB) vs. percent open boll in harvest timing studies conducted at the University of Georgia Coastal Plain Experiment Station in 1998, 1999, and 2000. **Denotes significance at the $P = 0.01$ level.

% 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 Inhibitiors [Aim, ET, 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 2023 Mid-South Cotton Defoliation Guide (by T. Raper, B. Pieralisi, M. Foster, T. Sandlin, S. Brown, and B. Wilson) at https://news.utcrops.com/wp-content/uploads/2023/09/W376_2023.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 regrowth 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.

On-target application of all pesticides is critical for Georgia growers to remain sustainable. Let's not get to the finish line on a cotton crop and throw all of our drift mitigation measures out the window. Utilize the lessons learned through UPW training to apply all pesticides on target, including cotton defoliants.

Table 11. Rain-Free Preiod for Selected Cotton Defoliants.

Product	Common Name	Rain-Free Period[1] (hr)	Company
Aim	carfentrazone-ethyl	6–8	FMC Corporation
Display	carfentrazone + fluthiacet	6–8	FMC Corporation
Boll Buster	ethephon	6	Loveland Products, Inc.
Boll'd	ethephon	6	Winfield Solutions, LLC.
Ethephon 6	ethephon	6	Arysta U.S.A.
Setup 6SL	ethephon	6	ADAMA Group
Super Boll	ethephon	6	Nufarm Americas Inc.
Finish 6 Pro	ethephon + cyclanilide	6	Bayer CropScience
Resource	flumiclorac	1	Valent U.S.A.
Blizzard	fluthiacet-methyl	1	Chemtura
ET	pyraflufen ethyl	1	Nichino America
Sharpen	saflufenacil	1	BASF
Defol 5	sodium chlorate	24	Drexel
Reviton	tiafenacil	1	HELM Agro
Daze 4SC	thidiazuron	24	Winfield Solutions
Freefall SC	thidiazuron	24	Nufarm Americas
Klean-Pik 500SC	thidiazuron	24	ADAMA Group
Takedown SC	thidiazuron	24	Loveland Products
Thidiazuron 4SC	thidiazuron	24	Arysta Lifescience
Adios	thidiazuron + diuron	12	Arysta U.S.A.
Cutout	thidiazuron + diuron	12	Nufarm Americas
Ginstar	thidiazuron + diuron	12	Bayer CropScience
Redi-Pik 1.5EC	thidiazuron + diuron	12	ADAMA Group
Folex	tribufos	1	Amvac Chemical

[1]Expected rain-free periods are estimates only and other conditions, including temperature, moisture, and crop status may play a role in product performance. See specific labels for more information.

COTTON DEFOLIATION / HARVEST AID OPTIONS

Camp Hand and Stanley Culpepper, Extension Agronomy and Weed Science

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 gal/a by air and 10–20 gal/a by ground.

Reduced performance issues are often related to low spray volume and poor canopy penetration. Fields should 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	HERBICIDE	BROADCAST RATE/aCRE (The rates below are given in the broadcast amount per acre unless otherwise noted)			REMARKS AND PRECAUTIONS
		EARLY-SEASON (highs 90°F plus, lows 70°F plus)	MID-SEASON (highs 80–89°F, lows 60–70°F)	LATE-SEASON* (highs below 80°F, lows below 60°F)	
Defoliation Only (combinations provide more consistent defoliation than a single product)	*carfentrazone ethyl* Aim 2.0EC	0.75–1 fl oz	0.75–1 fl oz	1 fl oz	Add non-ionic surfactant at 0.25% v/v during early-season and with 1 oz/a rate; add COC for 0.75 oz rate mid-season. The potential for leaf sticking is greater during periods of high temperatures.
	carfentrazone ethyl + *fluthiacet-methyl* Display 2.05EC	Up to 1 fl oz	Up to 1 fl oz	Up to 1 fl oz	Limited data, adhere to label restrictions, use precaution.
	flumiclorac Resource 0.86EC	4-6 fl oz	4-6 fl oz	4-6 fl oz	Add crop oil at 1–2 pt/a. Limited data, use precaution. The potential for leaf sticking is greater during periods of high temperatures. Label allows rate up to 8 fl oz.
	fluthiacet-methyl Blizzard 0.91EC	0.5–0.6 fl oz	0.5–0.6 fl oz	0.5–0.6 fl oz	Add crop oil at 1 pt/a. Limited data, use precaution.
	pyraflufen ethyl ET 0.208EC	1.5 fl oz	1.5 fl oz	1.5 fl oz	Add crop oil at 0.5% v/v early-season and increase rate to 1% in cooler conditions. The potential for leaf sticking is greater during periods of high temperatures. Label allows rate up to 2.75 oz/a.
	sodium chlorate Defol 5SL, others	3 lb ai	4 lb ai	4 lb ai	Apply to mature foliage only. Do not mix with products containing *tribufos* or *ethephon*. Label allows a maximum use rate of 6 lb ai.
	tiafenacil Reviton 2.83SC	0.5 oz	0.75 – 1 oz	1 – 1.5 oz	Label recommends a crop oil or methylated seed oil be included at 1% v/v, or a nonionic surfactant at 0.25% v/v. Label allows a maximum use rate of 3oz/acre in a single application, and only 6 oz/acre per season.
	tribufos Folex 6EC, others	1–1.5 pt	1–1.5 pt	X	Reduce rate to 1.25 pt if above 94°F.
	thidazuron + *diuron* Ginstar 1.5EC, others	X	X	8–10 oz	Limited data are available.
	tribufos Folex 6EC + *paraquat* Gramoxone 3S, others	X	X	1.5 pt + 2–8 oz	May cause crop desiccation and damage to unopened bolls.

**Late-season defoliations may require a preconditioning treatment to be successful (see preconditioning section). X = denotes product not suggested during those environmental conditions.*

HARVEST-AID FUNCTION	HERBICIDE	BROADCAST RATE/aCRE (The rates below are given in the broadcast amount per acre unless otherwise noted) EARLY-SEASON (highs 90°F plus, lows 70°F plus)	MID-SEASON (highs 80–89°F, lows 60–70°F)	REMARKS AND PRECAUTIONS
Regrowth control and defoliation	*thidiazuron* Dropp 4SC, others	3.2 fl oz	3.2 fl oz	For **maximum** regrowth control. *Thidiazuron* is sensitive to wash-off when rain occurs within 24 hours and may be vulnerable through 12 hours after application. Addition of *tribufos* (4–8 oz) or *ammonium sulfate* (2 lb/a) enhances rain fastness.
	thidiazuron + *diuron* Ginstar 1.5EC, others	6.4–8 fl oz	6.4–8 fl oz	Limited data are available on these products. Regrowth control is minimal when these products are applied at rates below 6.4 fl oz.
	thidiazuron Dropp 4SC, others + **ONE OF THE FOLLOWING:**	1.6–2.5 fl oz +	2–2.5 fl oz +	Label allows rate to be increased to 3.2 fl oz.
	carfentrazone ethyl Aim 2.0EC	0.75 fl oz	0.75–1 fl oz	Add non-ionic surfactant at 0.25% v/v during early-season and with 1 oz/a rate; add COC for 0.75 oz rate mid-season. The potential for leaf sticking is greater during periods of high temperatures.
	tribufos Folex 6EC, others	4–16 fl oz	1 pt	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. Maximum use rate when mixed with Dropp is 24 fl oz/a.
	tiafenacil Reviton 2.83SC	0.5 oz	0.75 – 1 oz	Label recommends a crop oil or methylated seed oil be included at 1% v/v, or a nonionic surfactant at 0.25% v/v. Label allows a maximum use rate of 3oz/acre in a single application, and only 6 oz/acre per season.
	carfentrazone ethyl + *fluthiacet-methyl* Display 2.05EC	up to 1 fl oz	up to 1 fl oz	Limited data, adhere to label restrictions, use precaution.
	flumiclorac Resource 0.86EC	4–6 fl oz	4–6 fl oz	Add crop oil at 1 pt/a during early-season and 1–2 pt/a during mid-season. Limited data, use precaution. Label allows rate up to 8 fl oz.
	fluthiacet-methyl Blizzard 0.91EC	0.5–0.6 fl oz	0.5–0.6 fl 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 0.208EC	1.5 fl oz	1.5 fl oz	Add 0.5% v/v crop oil during early-season and 1% during mid-season. Label allows rate up to 2.75 fl oz.

HARVEST-AID FUNCTION	HERBICIDE	BROADCAST RATE/aCRE (The rates below are given in the broadcast amount per acre unless otherwise noted) EARLY-SEASON (highs 90°F plus, lows 70°F plus)	MID-SEASON (highs 80–89°F, lows 60–70°F)	LATE-SEASON* (highs below 80°F, lows below 60°F)	REMARKS AND PRECAUTIONS
Boll Opening and Defoliation	*ethephon* Prep 6SC, others	2–2.67 pt	2–2.67 pt	2–2.67 pt	
	ethephon Prep 6SC, others + **ONE OF THE FOLLOWING:**	1.33–1.5 pt +	1.5–2 pt +	2–2.67 pt +	
	Carfentrazone ethyl Aim 2.0EC	0.75 fl oz	0.75–1 fl oz	1 fl oz	Add 0.25% v/v non-ionic surfactant at the 0.75 oz rate when conditions are warm/hot. Use crop oil 1% v/v when cooler.
	carfentrazone ethyl + *fluthiacet-methyl* Display 2.05EC	up to 1 fl oz	up to 1 fl oz	up to 1 fl oz	Limited data, adhere to label restrictions, use precaution.
	flumiclorac Resource 0.86EC	4–6 fl oz	4–6 fl oz	4–6 fl oz	Add 1–2 pt/a crop oil. Limited data, use precaution. Label allows rate up to 8 fl oz.
	fluthiacet-methyl Blizzard 0.91EC	0.5–0.6 fl oz	0.5–0.6 fl oz	0.5–0.6 fl oz	Add 1 pt/a crop oil. Limited data, use precaution.
	pyraflufen ethyl ET 0.208EC	1.5 fl oz	1.5 fl oz	1.5 fl oz	Add 0.5% v/v crop oil during early season and 1% during mid- and late-season. Label allows rate up to 2.75 fl oz.
	tiafenacil Reviton 2.83SC	0.5 oz	0.75 – 1 oz	1 – 1.5 oz	Label recommends a crop oil or methylated seed oil be included at 1% v/v, or a nonionic surfactant at 0.25% v/v. Label allows a maximum use rate of 3oz/acre in a single application, and only 6 oz/acre per season.
	tribufos Folex 6EC, others	1–1.25 pt	1–1.25 pt	1–1.25 pt	
	thidiazuron Dropp 4SC, others	1.6 fl oz	1.6 fl oz	X	Label allows rate to be increased to 3.2 fl oz/a
	thidiazuron + *diuron* Ginstar 1.5EC, others	4–6 oz	6.4 fl oz	6.4 fl oz	Likelihood of "leaf sticking" is increased when applied at or above 5 oz in combinations of defoliants during early season conditions; rate of 4 oz suggested during periods of high temperatures.

**Late-season defoliations may require a preconditioning treatment to be successful (see preconditioning section). X = denotes product not suggested during those environmental conditions.*

HARVEST-AID FUNCTION	HERBICIDE	BROADCAST RATE/aCRE (The rates below are given in the broadcast amount per acre unless otherwise noted)		REMARKS AND PRECAUTIONS
		EARLY-SEASON (highs 90°F plus, lows 70°F plus)	MID-SEASON (highs 80–89°F, lows 60–70°F)	
Boll Opening and Defoliation (*continued*)	*ethephon* + *ureasulfate* FirstPick 2.28SC + **ONE OF THE FOLLOWING:**	1.75–2 qt +	2 qt +	Likelihood of leaf sticking is increased during periods of high temperatures.
	carfentrazone ethyl Aim 2.0EC	0.75 fl oz	0.75–1 fl oz	
	carfentrazone ethyl + *fluthiacet-methyl* Display 2.05EC	up to 1 fl oz	up to 1 fl oz	Limited data, adhere to label restrictions, use precaution.
	flumiclorac Resource 0.86EC	4–6 fl oz	4–6 fl oz	Add 1–2 pt/a crop oil. Limited data, use precaution. Label allows rate up to 8 fl oz.
	fluthiacet-methyl Blizzard 0.91EC	0.5–0.6 fl oz	0.5–0.6 fl oz	Add 1 pt/a crop oil. Limited data, use precaution.
	pyraflufen ethyl ET 0.208EC	1.5 fl oz	1.5 fl oz	Add 0.5% v/v crop oil during early season and 1% during mid- and late-season. Label allows rate up to 2.75 fl oz.
	tiafenacil Reviton 2.83SC	0.5 oz	0.75 – 1 oz	Label recommends a crop oil or methylated seed oil be included at 1% v/v, or a nonionic surfactant at 0.25% v/v. Label allows a maximum use rate of 3oz/acre in a single application, and only 6 oz/acre per season.
	tribufos Folex 6EC, others	4–6 fl oz	6–8 fl oz	FirstPick label allows one to increase Folex rate up to 12 oz/a but be careful to avoid leaf sticking.
	thidiazuron Dropp 4SC, others	1.6 fl oz	1.6 fl oz	Label allows rate to be increased up to 3.2 fl oz/a.
	thidiazuron + *diuron* Ginstar 1.5EC, others	4–6 fl oz	5–6 fl oz	Likelihood of "leaf sticking" is increased when applied at or above 5 oz in combinations of defoliants during early season conditions; rate of 4 oz suggested during periods of high temperatures.

**Late-season defoliations may require a preconditioning treatment to be successful (see preconditioning section). X = denotes product not suggested during those environmental conditions.*

HARVEST-AID FUNCTION	HERBICIDE	BROADCAST RATE/aCRE (The rates below are given in the broadcast amount per acre unless otherwise noted) EARLY-SEASON (highs 90°F plus, lows 70°F plus)	MID-SEASON (highs 80–89°F, lows 60–70°F)	LATE-SEASON* (highs below 80°F, lows below 60°F)	REMARKS AND PRECAUTIONS
Boll Opening and Defoliation (*continued*)	*ethephon* + *cyclanilide* Finish 6 PRO + **ONE OF THE FOLLOWING:**	1.33–1.5 pt +	1.33–1.5 pt +	1.75–2 pt +	
	carfentrazone ethyl Aim 2.0EC	0.75 fl oz	0.75–1 fl oz	1 fl oz	Add 0.25% v/v non-ionic surfactant at the 0.75 oz rate when conditions are warm/hot. Use crop oil 1% v/v when cooler.
	carfentrazone ethyl + *fluthiacet-methyl* Display 2.05EC	up to 1 fl oz	up to 1 fl oz	up to 1 fl oz	Limited data, adhere to label restrictions, use precaution.
	flumiclorac Resource 0.86EC	4–6 fl oz	4–6 fl oz	4–6 fl oz	Add 1–2 pt/a crop oil. Limited data, use precaution. Label allows rate up to 8 fl oz.
	fluthiacet-methyl Blizzard 0.91EC	0.5–0.6 fl oz	0.5–0.6 fl oz	0.5–0.6 fl oz	Add 1 pt/a crop oil. Limited data, use precaution.
	pyraflufen ethyl ET 0.208EC	1.5 fl oz	1.5 fl oz	1.5 fl oz	Add 0.5% v/v crop oil during early season and 1% during mid- and late-season. Label allows rate up to 2.75 fl oz.
	tiafenacil Reviton 2.83SC	0.5 oz	0.75 – 1 oz	1 – 1.5 oz	Label recommends a crop oil or methylated seed oil be included at 1% v/v, or a nonionic surfactant at 0.25% v/v. Label allows a maximum use rate of 3oz/acre in a single application, and only 6 oz/acre per season.
	tribufos Folex 6EC, others	4–6 fl oz	6–8 fl oz	8–12 fl oz	
	thidiazuron Dropp 4SC, others	1.6 fl oz	1.6 fl oz	X	
	thidiazuron + *diuron* Ginstar 1.5EC, others	4–6 fl oz	5 fl oz	6 fl oz	Likelihood of "leaf sticking" is increased when applied at or above 5 oz in combinations of defoliants during early season conditions; rate of 4 oz suggested during periods of high temperatures.

**Late-season defoliations may require a preconditioning treatment to be successful (see preconditioning section). X = denotes product not suggested during those environmental conditions.*

HARVEST-AID FUNCTION	HERBICIDE	BROADCAST RATE/aCRE (The rates below are given in the broadcast amount per acre unless otherwise noted) EARLY-SEASON (highs 90°F plus, lows 70°F plus)	MID-SEASON (highs 80–89°F, lows 60–70°F)	REMARKS AND PRECAUTIONS
Boll Opening, Regrowth Control, and Defoliation	*ethephon* Prep 6SC, others + **ONE OF THE FOLLOWING:**	1.33–1.5 pt +	1.5–2 pt +	Limited data are available for some products. *Thidiazuron* rate may be increased to 3.2 fl oz. Regrowth control is minimal when *thidiazuron + diuron* is applied at rates below 6.4 fl oz.
	thidiazuron Dropp 4SC, others	2–2.5 fl oz	2–2.5 fl oz	
	thidiazuron + *diuron* Ginstar 1.5EC, others	6.4 fl oz	6.4–8 fl oz	
	ethephon Prep 6SC, others + *thidiazuron* Dropp 4SC, others + **ONE OF THE FOLLOWING:**	1.33–1.5 pt + 2–2.5 fl oz +	1.5–2 pt + 2–2.5 fl oz +	*Thidiazuron* rate may be increased to 3.2 fl oz
	carfentrazone ethyl Aim 2.0EC	0.75 fl oz	0.75–1 fl oz	Add non-ionic surfactant at 0.25% v/v during early-season and with 1 oz/a rate; add COC for 0.75 oz rate mid-season. The potential for leaf sticking is greater during periods of high temperatures.
	tiafenacil Reviton 2.83SC	0.5 oz	0.75 – 1 oz	Label recommends a crop oil or methylated seed oil be included at 1% v/v, or a nonionic surfactant at 0.25% v/v. Label allows a maximum use rate of 3oz/acre in a single application, and only 6 oz/acre per season.
	tribufos Folex 6EC, others	6–12 fl oz	8–12 fl oz	
	carfentrazone ethyl + *fluthiacet-methyl* Display 2.05EC	up to 1 fl oz	up to 1 fl oz	Limited data, adhere to label restrictions, use precaution.
	flumiclorac Resource 0.86EC	4 fl oz	4 fl oz	Add crop oil at 1–2 pt/a; lower rate under hot conditions. Limited data, use precaution. Label allows rate up to 8 fl oz.
	fluthiacet-methyl Blizzard 0.91EC	0.5–0.6 fl oz	0.5–0.6 fl oz	Add crop oil at 1 pt/a. Limited data, use precaution.
	pyraflufen ethyl ET 0.208EC	1.5 fl oz	1.5 fl oz	Add 0.5% v/v crop oil during early-season and 1% during mid-season. Label allows rate up to 2.75 fl oz.

HARVEST-AID FUNCTION	HERBICIDE	BROADCAST RATE/aCRE (The rates below are given in the broadcast amount per acre unless otherwise noted)		REMARKS AND PRECAUTIONS
		EARLY-SEASON (highs 90°F plus, lows 70°F plus)	MID-SEASON (highs 80–89°F, lows 60–70°F)	
Boll Opening, Regrowth Control, and Defoliation (*continued*)	*ethephon + urea sulfate* FirstPick 2.28SC **OR** *ethephon + cyclanilide* Finish 6 PRO + **ONE OF THE FOLLOWING:**	1.75–2 qt **OR** 0.33–1.5 pt +	2 qt **OR** 1.5–2 pt +	Likelihood of "leaf sticking" is increased when temperatures exceed 94°F.
	thidiazuron Dropp 4SC, others	1.6–2 fl oz	2–2.5 fl oz	
	thidiazuron + diuron Ginstar 1.5EC, others	6.4 fl oz	6.4–8 fl oz	Limited data are available with some of these products. Regrowth control is minimal when these products are applied at rates below 6.4 oz.

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 7–10 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	HERBICIDE	BROADCAST RATE/aCRE	REMARKS AND PRECAUTIONS (The rates below are given in the broadcast amount per acre unless otherwise noted)
Initial Preconditioning Treatment	*carfentrazone-ethyl* Aim 2.0EC	1 fl oz	Add 1% v/v crop oil.
	carfentrazone-ethyl + fluthiacet-methyl Display 2.05EC	up to 1 fl oz	Limited data, adhere to label restrictions, use precaution.
	ethephon Prep 6SC, others	0.67–1.33 pt	
	flumiclorac Resource 0.86EC	4 fl oz	Add 1–2 pt crop oil. Label allows rate up to 8 fl oz.
	fluthiacet-methyl Blizzard 0.91EC	0.5–0.6 fl oz	Add 1 pt crop oil.
	pyraflufen ethyl ET 0.208EC	0.3–0.75 fl 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 6EC	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

Camp Hand and Stanley Culpepper, Extension Agronomy and Weed Science

HERBICIDE	BROADCAST RATE/ ACRE	REMARKS AND PRECAUTIONS (The rates below are given in the broadcast amount per acre unless otherwise noted.)
carfentrazone-ethyl Aim 2.0EC	1 fl oz	Add 1% v/v crop oil. Effective on morningglory, coffee senna, and tropical spiderwort.
carfentrazone-ethyl + fluthiacet-methyl Display 2.05EC	up to 1 fl oz	Limited data, adhere to label restrictions, use precaution.
glyphosate Roundup Powermax 3 5.88S, others	up to 2.5 pts	Use in combination with defoliants.
paraquat Gramoxone 3S, others Gramoxone Inteon 2S	 1–4 fl oz 3–5 fl oz	Use in combinations with standard defoliation applications. May cause crop desiccation and damage to unopened bolls.
pyraflufen ethyl ET 0.208EC	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. Label allows rate to be increased to 2.75 fl oz/a.
Follow-up Treatments Desiccants *paraquat* or *sodium chlorate*	See Desiccants for Cotton Harvest Preparation (below).	

DESICCANTS FOR COTTON HARVEST PREPARATION

Camp Hand and Stanley Culpepper, Extension Agronomy and Weed Science

DESICCANT	FORMULATION (lb ai/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 85% open. Improves activity in colder, late-season conditions. May cause crop desiccation and damage to unopened bolls.
Firestorm	3	5.4 fl oz	10–20	5	
Gramoxone Inteon	2	3–5 fl oz	10–20	5	
Gramoxone Max	3	1–4 fl oz	10–20	5	
Parazone	3	5.4 fl oz	10–20	5	
paraquat					For desiccation of weeds and cotton regrowth after defoliation. Add surfactant at 1–2 qt/100 gal of spray solution. Be prepared to harvest in a timely manner (3 to 5 days ideally) to minimize bark problems. May cause crop desiccation and damage to unopened bolls.
Gramoxone Max	3	5.5 oz–1.5 pt	10–20	5	
Firestorm	3	0.7–1.3 pts	10–20	5	
Parazone	3	0.7–1.3 pts	10–20	5	
Gramoxone Inteon	2	1–2 pt	10–20	5	
sodium chlorate	4–6	3–6 lb ai	10–20	5–10	

PERFORMANCE RATING OF HARVEST AIDS BY FUNCTION

Camp Hand and Stanley Culpepper, Extension Agronomy and Weed Science

CHEMICAL 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, etc.	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

UGA "THREE-WAY" DEFOLIATION MIXTURE RECOMMENDATIONS BY TEMPERATURE

Camp Hand and Stanley Culpepper, Extension Agronomy and Weed Science

SEASON (TEMPERATURES)	*ETHEPHON* (PREP 6SC)	*THIDIAZURON* (DROPP 4SC)	*TRIBUFOS* (FOLEX 6EC)
	BROADCAST RATE/aCRE		
Early Season (highs >90° F, lows >70° F)	21–24 fl oz	1.6–3.2 fl oz	6–12 fl oz
Mid-Season (highs 80–89° F, lows 60–70° F)	24–32 fl oz	2–4 fl oz	8–12 fl oz
Late-Season (highs <80° F, lows <60° F)	32–42 fl oz	X	16–20 fl oz

Ethephon—Higher rates necessary with cooler temperatures to increase boll opening.
Thidiazuron—Increase rates for greater regrowth potential, less activity when lows are less than 65°F for 3 days.
Tribufos—Higher rates necessary for cooler temperatures, however too high can dessicate. X = denotes product not suggested during these environmental conditions.

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 moisture 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 satisfactorily. Keep harvested seed cotton dry.

Modules

Several factors have an impact on the effectiveness of the module 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.

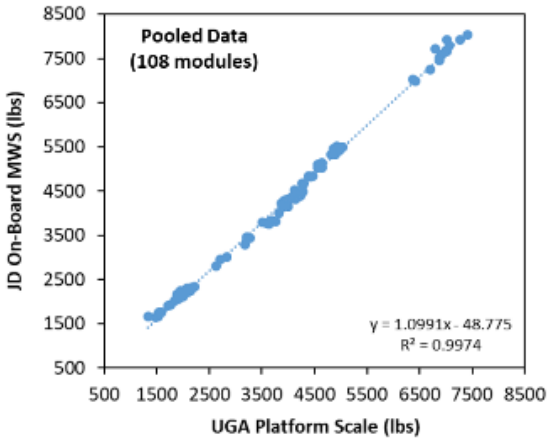
Handling - Place modules on a firm surface accessible to trucks in wet weather. Do not till the soil on the truck approach side of the module. The surface in front of the module needs to be firm for the module hauler to retrieve the module without stretching it. Leave enough room in front of the module 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.

Yield Monitor and New Technology

Currently, there are two types of cotton yield monitors (John Deere and Ag Leader) available on the cotton pickers, however the Ag Leader yield monitor is no longer offered for purchase. A yield monitor can help identify low and high yield areas (spatial yield variability) within a field and how management practices that may be limiting yield can be changed to maximize productivity across the whole field. Yield data from an uncalibrated yield monitor can provide misleading or false information about yield variability, therefore it is critical to property setup and calibrate the yield monitor prior to harvest. Remember that yield data quality is only as good as the calibration so make sure to spend time in properly calibrating the yield monitor. A timely and thorough pre-harvest check can minimize downtime and technology issues during the harvest. Make sure that mass flow sensors are clean and free of any debris or obstructions, wiring harnesses are not damaged and connected properly, and all other sensors (header height, GPS and in-cab display) are installed and functioning correctly. Regular checks on yield monitor functioning and yield data should be performed during harvest to avoid recording erroneous data. Research has shown that change in variety and/or field conditions can affect yield data quality, therefore additional calibration checks may be required in these situations to maintain data accuracy and quality. Yield data should be exported and transferred to a computer or cloud storage immediately after finishing the harvest.



Both Case and John Deere have developed cotton pickers with on-board capacity to construct modules or something similar. John Deere also offers on-board module weighing system and moisture sensing capabilities on their CP690 and new CP770 cotton pickers that can provide individual round module weights and moisture content during harvest. Preliminary evaluation work conducted from 2018 to 2020 suggested that the accuracy of the on-board module weighing system was consistently above 90% when compared to a calibrated platform scale. The system needs to be calibrated properly before harvest and the cotton picker needs to be stopped completely when module is finished and weighed. Further 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.

Contamination-Free Cotton

High yields and superior fiber quality are goals that all Georgia cotton producers strive to achieve, therefore awareness and prevention of lint contamination ensure that potential risks are avoided and that our products remain marketable. Cotton producers are competing with man-made fibers and foreign cotton in today's marketplace. One of cotton's greatest attributes, its pure and natural quality, can be degraded by a variety of contaminants. This impairs producers' relationships with textile manufacturers and also undermines the industry's "value added" promotion activities.

Each year as cotton harvest season begins, it is important that producers have to be vigilant to keep contaminants out of their cotton. There have been reports of bales being sent back to gins, and customers moving elsewhere because of plastic issues. The cotton industry is committed to improving this situation for all along the cotton supply chain.

Foreign materials are simply anything but lint and seed that is mixed into the cotton during harvest or during or after processing. Contaminants can range from bark to plastic bags to bale wrap. Not only can foreign materials inadvertently make it into yarns and fabrics, but they can also degrade the crop. These things can very easily be taken in by harvesting equipment.

Always remember: it is easier to prevent contamination than it is to remove contaminants from baled or ginned cotton.

Consider the following:

Educate. Before harvest, growers should educate employees by creating a foreign material watch list, and posting that list in farm equipment cabs. Once that education is complete, workers can then identify and abate any potential contaminants in the field by stopping what they are doing to remove the foreign materials in the field.

Start Clean. Begin the harvest season with clean equipment. For growers who use the new picker/balers, it is important to make sure that the equipment is not rubbing or puncturing the bale wrap and that the wrap is adhering in the correct places, as to not have any yellow or pink plastic lodged in the cotton.

During Harvest. Crews must understand the consequences of allowing harvesting equipment to pick up foreign material. Be sure to inspect equipment daily and do not allow modules to be built or placed in areas where potential contaminations will be picked up with modules. Do not drop or build modules in standing or shredded stalks. Use a method to identify modules without marking seed cotton. Keep modules elevated. Transport modules at a height above cotton stalks and place them at a flat, clean spot with a bit of space between them.

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.**

Trade and brand names are used only for information. The University of Georgia College of Agricultural and Environmental Sciences Cooperative Extension does not guarantee nor warrant the standard of any product mentioned neither does it imply approval of any product to the exclusion of others which may also be suitable.

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