Volunteer Peanut (*Arachis hypogaea* L.) Control in Glyphosate/Glufosinate Resistant Cotton (*Gossypium hirsutum* L.)

by

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Abstract

The increase in conservation tillage along with the use of herbicide-resistant crops has changed the dynamics of weed populations and control methods with volunteer plants from the previous crop contributing to the weed community in subsequent rotations. In the southeastern U.S., a peanut-cotton rotation is very popular for disease, insect, weed, and nematode suppression; however, volunteer peanut plants can be challenging to control in cotton production. Field experiments were conducted in 2010 at the Gulf Coast and Wiregrass Research and Extension Centers to identify effective control strategies for volunteer peanut in cotton. RoundUp Ready® and LibertyLink® cotton was planted in plots where peanuts were produced in 2009. Plots were sprayed at the cotton's 2-leaf, 4-leaf, or 2 and 4-leaf growth stage with either a postemergence (POST) glyphosate (1.12 kg ai ha^{-1}) or glufosinate (0.47 kg ai ha^{-1}) application alone or followed by trifloxysulfuron-sodium (0.005 kg ai ha^{-1}) applied at the 8-leaf growth stage. In addition, all plots received prometryn (1.12 kg ai ha^{-1}) + monosodium acid methanearsonate (MSMA) (2.24 kg ai ha^{-1}) as a post-directed spray (LAYBY) to cotton. At the Wiregrass Research and Extension Center, the 2-leaf or 4-leaf alone treatment provided ≤ 30% control. The 4+8-leaf treatment provided poor early control, < 55 %, but control increased to ≥ 65% over time. The best control was observed in the 2+4+8-leaf

and 2+8-leaf treatments. However, only 70-75% control was attained in this study indicating significant peanut survival. There was no significant difference in control of volunteer peanuts with glyphosate or glufosinate systems. At the Gulf Coast Research and Extension Center, better overall volunteer peanut control, ranging from 93% to 20% across all treatments, was observed.   The only treatment that provided significantly lower control than the weed free treatment at the late rating was the 2-leaf alone application at ≤ 20 % control.   At this location there was also an advantage in using a glufosinate system at both 4-leaf and 8-leaf ratings.

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Table of Contents

List of Figures

Introduction

Agriculture is America's most important export industry (ACES, 2000). In fact, agricultural exports averaged $40 billion in 2009. However, these export levels may not be sustainable with the continuous battles over water usage, increased energy costs, and climatic changes (Batie and Healy, 2009). One American farmer feeds 130 people each year, 25 who live overseas (ACES, 2000). Approximately seventy-nine cents of every dollar that the average American spends on food goes toward processing and marketing, leaving the farmer with only 21% to pay for all variable costs such as seed, fertilizers, herbicides, fungicides, diesel fuel in addition to fixed costs like tractors and facilities, leaving little net income for the farmer.

Cotton and peanut crop rotations. Peanut (*Arachis hypogaea* L.) and cotton (*Gossypium hirsutum* L.) crop rotations are typically grown in the southeast United States and are valuable to farmers for reducing nematode and disease pressure, which can aid in increasing yield. The rotation of peanut with cotton can reduce the number of peanut root-knot nematode [(*Meloidogyne arenaria* (Neal) Chitwood)] and increase yield while reducing nematicide usage (Rodriguez-Kabana, et al, 1986). A six-year study at the Wiregrass Research and Extension Center, Headland, AL. indicated that peanut yield following one or two years of cotton were consistently higher than continuous peanut plantings. In this experiment, the addition of a nematicide to continuous peanut rotation did not improve yields over the peanut-cotton rotation alone. Rodriguez-Kabana, et al (1991) determined that peanut root-knot populations were lowest following cotton. The same effect is seen with cotton root-knot nematode (*Meloidogyne incognita* Race 3) on peanut. Peanut is considered to be a 'passive' control measure for cotton root-knot

nematode, as it is simply a non-host (Rodriguez-Kabana and Canullo, 1992). Where high infestations of cotton root-knot nematodes are observed, rotating to peanut will decrease nematode numbers unlike monoculture systems of cotton or corn (*Zea maize* L.) (Kirkpatrick and Sasser, 1984).

Crop rotations also benefit cotton and peanut production in the southeastern United States by decreasing soil diseases. One economically important soil-borne disease that affects peanut growth and yield is southern stem rot, *Sclerotium rolfsii* Sacc. Southern stem rot can be reduced in peanut through rotation to crops like cotton, corn, or bahiagrass (Rodriguez-Kabana, et al, 1991; Mullen, 2006). The incidence of southern stem rot is typically found to be greater when shorter rotation intervals away from peanut are attempted. In 1993, Bowen, et al found that southern stem rot had a higher degree of occurrence in fields cropped to peanut every other year compared to longer rotations. Other production practices used for managing southern stem rot include fungicides and inversion tillage. For many years producers fought this disease with inversion tillage as their only tool. However, research has shown a direct relationship in organic matter at the soil surface to peanut losses from southern stem rot (Brenneman, et al, 1999). Recently discovered fungicides with increased effectiveness on southern stem rot have decreased the need for tillage. However, they are only partially effective in decreasing the risk of large losses of peanut yield and quality of peanut (Hagan, et al, 2001).

Conservation tillage in Southern row crops. Conservation tillage is becoming widely adopted by row crop growers in the U.S. Of the 2.9 million hectares of cotton planted in 2004, nearly half was planted in some form of conservation tillage an increase from prior years (CTIC, 2004). Conservation tillage can result in reduced soil erosion, fuel

consumption and subsequent wear on equipment, while increasing water infiltration and retention in the soil (Hook, 1999). Increased use of conservation tillage results in a potential shift in weed communities (Locke et al, 2002). Noted changes include increased perennial grasses and volunteer crops that act as weeds (Derksen, et al, 1993). With reduced inversion tillage practices, many producers have relied solely on postemergencence herbicides for weed control. Conservation tillage and decreased tillage intensity by farmers has increased the occurrence of volunteer weeds from the previous year's crop (Johnson III et al, 2000).

In Southeastern U.S., volunteer peanut is a reoccurring pest in cotton production. A "volunteer peanut" is a peanut from the previous season(s) that survives the winter and emerges from the soil the following spring, competing with that crop for water, nutrients, and sunlight. Volunteer peanut seed is created by harvest losses during the previous year. These losses may be caused by harvesting plants that are past maturity, harvesting when soils are exceptionally wet or dry, improperly operated harvest equipment, and/or weed roots that interfere with peanut digging and inverting.

Peanut maturity and harvest. Peanut maturity is difficult to measure because it is botanically considered indeterminate, with maturity often corresponding with summer rainfalls on non-irrigated fields (Windham, et al, 2010). This creates a difficult scenario when attempting to estimate maturity of the crop. The "hull scrape" method is the current standard for producers as well as extension agents in determining the optimum time for inverting the crop. Knowledge of pod maturity distributions leads producers to an estimated optimum digging time that can increase yield as well as market grades. The hull scrape method can be accurate but there are also several limitations, including: (1)

subjective judgment of observer, (2) labor and time of sampling and scrapping hulls, and (3) labor and time of categorizing hulls (Windham, et al, 2010). These limitations push producers toward testing the earliest planted fields and then harvesting fields in the order of planting. Peanut yield is dependent on many factors; digging one week prior or one week later than optimum maturity can result in great reductions in pod yield (Wright and Porter, 1991; Carley, et al, 2009). Research conducted by Wright and Porter in 1990 found that digging peanuts eight to eleven days before or after the optimum digging date reduced yields and value of crop. Early peanut harvest reduced yields 15% while harvesting late reduced yields 6%. The subsequent value of early harvested peanuts was reduced 21%, while digging late reduced value by 5% (Wright and Porter, 1991).

Harvesting peanuts in dry and wet soils. Peanut harvest occurs during hurricane season in the southeastern United States. These tropical systems can bring large amounts of rain that interfere with peanut harvest season. October is also historically the driest month of the year for the Southeast (AWIS, 2012). Quantifying losses from harvesting peanuts can fluctuate significantly due to many external influences outside of peanut maturity and weather. These can include, but are not limited to, peg strength differences in varieties (Thomas et al, 1983), soil structure, and precision of harvest equipment (Balkcom, et al, 2010).

Peanut harvest losses. Another reason for excessive peanut losses during harvest is the improper placement of harvest equipment while inverting. When inverting peanut vines, the tractor operator must maintain the equipment precisely over the peanut rows.   By deviating from the rows, the blades or points of the inverter that are cutting the peanut taproot begin to dislodge peanuts from the vine causing high pod losses during harvest

4

(Balkcom et al, 2010). Deviations from the center of the rows as small as 9 cm can reduce yields as much as 15%. Deviations from the row center as much as 18 cm can reduce yields as much as 32% (Balkcom, et al, 2010). If a farmer is harvesting 3920 kg ha^{-1} at \$672/metric ton and is off 9 cm or 18 cm, they could potentially be losing \$70 ha^{-1} or \$150 ha^{-1}, respectfully. Besides yield and profit, peanuts dislodged during digging remain in the ground and emerge the next spring. Although the seed will be at various depths, they will germinate under a wide range of environmental circumstances (TCE, 2007).

Weed competition in peanuts. Peanut yield loss from weed competition is dependent on factors such as soil moisture at harvest, density, species complex, length of competition, and weed growth habits (Everman et. al, 2008). Because peanuts have a slow prostrate growth habit, broadleaf weeds can easily develop a canopy above crop foliage. In weed competition studies, Everman et al, (2008) demonstrated that growers can suffer appreciable yield loss with poor weed management in the first eight weeks. Weed interference starting as early as three weeks after planting can decrease yields. As the longevity of weed competition increases, the peanut yield decreases. One way producers combat the slow canopy closure growth habits of peanut is to plant in twin-rows. This creates narrower row middles and allows the plants to close open row middles faster. Brecke and Stephenson (2006) indicated that weeds such as Florida beggarweed [(*Desmodium tortuosum* (Schwartz) DC)] and sicklepod (*Senna obtusifolia* L.) had a higher rate of control in twin row over single row planting patterns. Twin-row planting patterns have been shown to consistently increased yields (Wehtje, et al, 1984; Everman et. al, 2008).

Cotton weed management. The importance of weed management for successful cotton production has been well-documented through yield increases via weed control (Askew and Wilcut, 1999; Morgan et al, 2001; Buchanan et al, 1980). The goal of weed management is the reduction of weeds through planning and population assessments while using various management tools (Burnside, 1992). There are several methods of controlling weeds including physical, cultural, mechanical, and chemical control. Management decisions that include selecting a vigorous variety, proper seedbed preparation, planting when soil is warm and moist, use of good seed, and proper soil fertility and pH can be employed so the cotton plants have the opportunity to compete against weeds (McWhorter and Abernathy, 1992).

Farmers often start planting crops early in the spring to take advantage of seasonal rainfall patterns as well as plant all their acreage in a timely manner. Many times conditions are not conducive for cotton to grow vigorously because the soil is cold and wet. If the crop struggles to grow then weeds can flourish. In early spring, large temperature variations can occur from day to day in the cotton belt. A common rule that southeastern U.S. producers use specifies that the soil temperature at the 20 cm depth should average 15.5 degrees C for a 10-day period before planting is initiated (Mauney and Stewart, 1986). Fields can be located in distant proximity to primary infrastructure making it very difficult to be timely with herbicide applications. Weed control methods have changed drastically over the last century. Hand tools and animal-powered cultivators were the 1900's cotton farmer's primary tools for managing weeds before the development of tractors, and herbicides (McWhorter and Abernathy, 1992). The goal of

cultivation was to eliminate and prevent the emergence or growth of weeds and grass that reduced yields and grades (Sturkie and Williamson, 1951) without injuring the crop.

In the last 15 years, cultivation decreased and gave way to conservation tillage and herbicides mainly due to the introduction of glyphosate resistant crops in 1997 (Faircloth et al, 2001). Glyphosate was initially utilized in controlling perennial weeds on ditch banks, right of ways, and fallow fields. However, because of the absence of resistance by crops, its uses in agriculture were limited. The increase of conservation tillage and no-till practices along with herbicide-tolerant crops significantly increased the utility and use of glyphosate (Nandula, 2010).

Along with glyphosate, the herbicide glufosinate has aided the transition into conservation tillage by being a nonselective herbicide incorporated into resistant crops. Glufosinate has also become a tool for farmers in battle against glyphosate resistant weeds such as Palmer amaranth (*Amaranthus palmeri* S. Wats.). Due to the ease of using glyphosate and its broad spectrum of weed control, farmers began to grow cotton in monoculture systems while relying on multiple applications of glyphosate exclusively for weed control (Culpepper et al, 2006; Gardner et al, 2006). This dependence on a single weed control system ultimately led to the development of glyphosate resistant weeds. Glufosinate resistant cotton was registered in 2004, which can be effective against glyphosate resistant weeds because of its ability to inhibit glutamine synthetase which leads to a buildup of ammonia in leaf tissues causing necrosis and death of leaves (Gardner et. al, 2006).

Volunteer peanut harboring effect on cotton production. Volunteer peanut harbors pests like the green stink bug (*Nezara viridula* L.) and the brown stink bug [*Euschistus servus* (Say)], that are detrimental to cotton production. Green and brown stink bugs that develop will often migrate to adjacent fields and feed on cotton bolls (Tillman, et al, 2009). In 2009, Smith and Davis (not published) investigated stink-bug control in cotton by planting four rows of cotton between adjacent rows of peanuts. This was to create an artificially high number of stink-bug pests to rate the efficacy of control methods at different application timings. At least 600% increase in seed cotton yields was realized by applying insecticide combinations for stink bug control. This indicated that, while stink bugs are not a major pest in peanut production, the crop can harbor damaging pests of cotton.

Controlling volunteer peanut in cotton.   There has been limited research on controlling volunteer peanuts due to adequate control through other means mentioned earlier such as inversion tillage. York et al (1994) reported that sequential applications of glyphosate were better than a single application for volunteer peanut control. Control with single applications of glyphosate also improved with increased rates. Regardless of the herbicide rate, volunteer peanut control improved when the peanut had a 20-30 cm diameter due to increased herbicide interception. York et al also showed that at least 80% control of volunteer peanut could be using glyphosate with single applications at high rates or sequential treatments. One limiting characteristic of this study was the use of spring planted peanut instead of volunteer peanut. William Birdsong, Alabama Cooperative Extension System Cotton Specialist for Southeastern Alabama, (personal contact, 2011) says many farmers have expressed the difficulty of controlling volunteer

peanuts with cotton herbicides, whereas glyphosate drift will kill spring planted peanut easily. Moisture stressed peanut is also more difficult to kill, which may be why sequential applications are preferred by producers (York, et al, 1994). The objective of this study was to determine the effectiveness of glyphosate (RoundUp Ready® system) and glufosinate (LibertyLink® system) for controlling volunteer peanut in cotton in south Alabama.

Materials and Methods

An experiment was implemented to determine effects of glyphosate and glufosinate on volunteer peanuts. Field studies were conducted in 2010 at the Gulf Coast Research and Extension Center (GCREC) in Fairhope, AL., a Malbis sandy loam soil (fine-loamy, siliceous, subactive, thermic Plinthic Paleudults), and at the Wiregrass Research and Extension Center, Headland (WREC), AL, a Dothan sandy loam (fine-loamy, kaolinitic, thermic Plinthic Kandiudults).

Both experiment sites were planted to peanut the season prior to cotton (2009). At WREC, the peanut crop was harvested in excessive soil moisture while the peanut crop at the GCREC was not harvest but tilled into the soil. The cotton varieties 'DPL 0935 BGIIRF' and 'FM 1845 BGIILL' were planted at both sites at the rate of 8.2 seed m^{-1} to the depth of 2.54 cm. Plot size was four rows spaced 92 cm apart and 7.62 m in length. Experimental design at both locations was a randomized complete block with treatments replicated four times.

Cotton was planted on May 18, 2010 at GCREC and on May 28, 2010 at WREC. At planting, a uniform broadcast application of pendimethalin (Prowl H_2O®, BASF Corporation, Research Triangle Park, NC) at 0.84 kg ha^{-1} + fomesafen (Reflex®,

Syngenta Crop Protection, Inc., Greensboro, NC) at 0.105 kg ha^{-1} was applied at both locations.

Treatments included glyphosate (RoundUp Power Max®, Monsanto Company, St. Louis, MO.) at 1.12 kg ha^{-1} & glufosinate (Ignite®, Bayer CropScience, Research Triangle Park) at 0.47 kg ha^{-1} applied at cotton's 2-leaf, 4-leaf, or 2+4-leaf alone or followed by an application of trifloxysulfuron-sodium (Envoke®, Syngenta Crop Protection, Inc., Greensboro, NC) at 0.005 kg ha^{-1} at the 8-leaf stage. Initial applications of glyphosate or glufosinate included S-metolachlor (Dual Magnum®, Syngenta Crop Protection, Inc., Greensboro, NC) at 0.14 kg ha^{-1}. All plots received prometryn (Caparol®, Syngenta Crop Protection, Inc., Greensboro, NC) at 1.12 kg ha^{-1} + monosodium acid methanearsonate (MSMA®, Drexel Chemical Company, Memphis, TN) at 2.24 kg ha^{-1} as a post-directed spray to cotton. Non-treated and weed free checks were included for comparison with non-treated excluded from statistical analysis. Glyphosate was pre-mixed with a non-ionic surfactant while a non-ionic surfactant (Top Surf®, Winfield Solutions, LLC. St. Paul, MN.) was added to glufosinate and trifloxysulfuron-sodium at 0.25% v/v. Herbicide applications were made with a pressurized CO_2 backpack sprayer delivering 145 L/ha with 11004 flat fan nozzle (TeeJet®, Spraying Systems Co., Glendale Heights, IL.).

Weed control ratings were visually estimated at 7 days after treatment (DAT) of 2-leaf, 10 DAT of 4-leaf, and 31 DAT of 8-leaf applications on a 0 to 100% scale with 0 being no control and 100 being complete control. In addition to peanut, grass species were identified and rated at both locations. The center two rows of cotton were harvested from each plot on September 23, 2010 at GCREC and October 21, 2010 at WREC with

percent lint determined by gin turn-out of plot samples at GCREC and by a constant 38% gin turn-out at WREC.

Data are presented by location due to significant main effects for yield and peanut control. Transformation of data did not improve homogeneity of variance. Yield data and weed control ratings were subjected to ANOVA (P=0.05) with PROC GLM in SAS (SAS version 9.2, SAS Institute Inc., Cary, NC).

Results and Discussion

Data analysis indicated a significant location*treatment interaction; therefore, control and yield data are presented separately by location.

Weed control. In the first volunteer peanut control rating (Figure 1) at the Wiregrass Research and Extension Center (WREC), there was no significant difference between any of the 2-leaf treatments. This is also true with the first grass complex control rating (Figure 2). The grass complex consisted of southern crabgrass (*Digitaria ciliaris* Retz.), bermudagrass (*Cynodon dactylon* L.), and broadleaf signalgrass (*Urochloa platyphylla* Munro ex C. Wright). There was exceptional control seen on these grasses early. This was likely due to control by the burn down herbicide application. Although pendimethalin was applied as a pre-emergent grass herbicide, escapes began to come through by the 4-leaf rating. This is evident in the 2-leaf and 4-leaf treatments where late season ratings were extremely low for grass control.

Following the second rating of volunteer peanut control at the WREC, 10 days after the 4-leaf treatment (Figure 3), the 2-leaf application alone decreases in percent control and is significantly lower than all other treatments except the 4-leaf treatment.

11

This is most likely due to the late emergence of volunteer peanut. The 4-leaf treatment alone is significantly lower most likely due to the volunteer peanut having a larger size before applications were made creating an environment that makes weed control difficult. However, York, et al, (1994) showed a higher percentage of control with larger peanut due to increase in herbicide interception. In this study, volunteer peanut was used whereas York et al used spring planted peanuts. Although 4-leaf applications had a low % control, by adding an 8-leaf application of trifloxysulfuron-sodium, an increase in volunteer peanut control was achieved. The % control of grasses for the 4-leaf application was significantly less than the 2-leaf or the 2+4-leaf applications most likely due to larger grass size at application timing (Figure 4).

The last rating showed the 2-leaf and 4-leaf applications alone significantly lower volunteer peanut control than the other treatments (Figure 5). Although there was not a significant difference in grass control %, the same pattern was also seen with numerical differences (Figure 6). The best control was seen in the 2+4+8-leaf and 2+8-leaf treatments. However, this was still only an 80%-85% control. There was no significant difference in control of volunteer peanuts with glyphosate or glufosinate at the first, second, or final ratings. However, there was a noticeable difference in grass control between technologies (Figure 7).

At the Gulf Coast Research and Extension Center (GCREC), better overall volunteer peanut control across all treatments was obtained over treatments at WREC. Several influencing factors could potentially include precipitation timing, early emergence of volunteer peanuts, and/or a shading effect from the cotton. The 2-leaf only treatment was significantly lower than all other treatments at the late rating (Figure 8).

This was most likely due to emergence of volunteer peanut after the first application. The weed free treatment, 4-leaf treatment, and the 2+4-leaf treatment had significantly higher control of volunteer peanut than the 2+4+8 and the 4+8 treatments. However, the 2+4+8-leaf and 4+8-leaf treatments had comparable control to the 2+4, 2+8, and weed free treatments in grass control while the 4-leaf treatment was significantly lower than the 2+4, 2+4+8, and weed free treatments (Figure 9). At WREC treatments with the 8-leaf application of trifloxysulfuron-sodium tended to increase late control of volunteer peanut, whereas at GCREC, those treatments were lower in control ratings. It is unclear what factors contributed to these location differences and more research is necessary to understand to what degree trifloxysulfuron efficacy is affected by environmental variability.

There was a similar trend with treatments at GCREC for the first ratings of volunteer peanuts and grass control as observed at WREC. For weed control at the 2-leaf application stage, volunteer peanut control was statistically the same for all treatments and lower than the weed free treatment (Figure 10). All 2-leaf applications for grass control were very high (Figure 11).

At the 4-leaf rating, the 2-leaf only treatment was significantly lower in volunteer peanut and grass control (Figure 12, Figure 13). This was more than likely due to the late emergence of grass or volunteer peanut that was not controlled by an early application alone. There was no significant difference in 2+4, 4-leaf, 4+8, or weed free treatments on volunteer peanut control. The 2-leaf treatment had significantly lower grass control than the 2+4, 2+4+8, and the weed free treatments.

There was also a significant difference in control of peanuts when comparing glufosinate and glyphosate at GCREC (Figure 14). With the first rating, there was no significant difference in glyphosate and glufosinate control of volunteer peanuts. By the second rating, 10 days after the 4-leaf application, glyphosate began showing a significant increase in % control of volunteer peanut and continued that trend until the last rating.

This same trend was seen in grass control at GCREC (Figure 15) with glyphosate being significantly better than glufosinate. High control ratings with glufosinate at the first rating for grasses could be attributed to contact injury caused by glufosinate on plant tissue. However, glufosinate does not translocate and kill the roots to provide complete control. Over time, glyphosate applications provided better grass control than glufosinate.

Cotton yield. At the Wiregrass Research and Extension Center (WREC) in Headland, AL, the 2+4+8-leaf application and the 2+8-leaf application treatments had significantly higher yields than the no control, 2-leaf, 4-leaf, and 2+4-leaf treatments (Figure 16). However, this is not attributed to significantly better volunteer peanut (Figure 5) or grass control (Figure 6) at season end. There was a noted difference in yields between technologies with glyphosate resistant hybrids having significantly higher yields than glufosinate resistant hybrids at WREC (Figure 17).

At the Gulf Coast Research and Extension Center, Fairhope, AL there was also a significant difference seen in yield (Figure 18). However, unlike Headland where two treatments were significantly different, Fairhope had five treatments among the top in yields. The 2-leaf treatment, 2+4-leaf treatment and the 4-leaf treatments were all

14

significantly higher than the 2+8-leaf and the no control treatments. One possible explanation for this is the amount of rainfall and timing of rainfall for Fairhope. The precipitation increased in August and September as bolls were increasing in size as well as maturing. During the months of August and September, Fairhope received a total of 40.56 cm of rainfall. This was not the case in Headland as they remained dry receiving a total of only 14.20 cm in both months (AWIS, 2012).

At both sites it was visible that one application of either glyphosate or glufosinate was not enough to completely control volunteer peanuts or various grasses. Where multiple applications were applied better control was generally observed.   Glyphosate seemed to have better control on grasses and volunteer peanut than glufosinate. Along with better control and technologies came higher yields. At WREC, the addition of trifloxysulfuron-sodium increased the control of volunteer peanut, whereas at GCREC that data was not found true. Although an increase in volunteer peanut control did not always equal an increase in cotton yields, the no control treatments were overtaken by volunteers as well as other weeds producing very little yield. Single applications of herbicides increased weed control over no applications while multiple applications of herbicides consistently increased weed control and yields over single applications.

In this study, no application timing or technology provided consistent superior performance in volunteer peanut control. More research is needed in timing of volunteer peanut emergence and competition level with cotton crop. This research is necessary to determine how many applications are needed to get the highest percent control of volunteer peanut and how volunteer peanut reduces cotton yields through direct competition.

References

[ACES] Alabama Cooperative Extension Center. 2000. Department of Agricultural Economics and Rural Sociology, College of Agriculture, Auburn University. ANR-1107.

[AWIS] Agricultural Weather Information Service, Inc. 2012. AU Mesonat Daily Climate Data. http://www.awis.com/forms/dasta.alawonda.html. Accessed March 19, 2012.

Arant, F. S., B. B. Higgins, R. W. Bledsoe, B. W. Smith, W. E. Colwell, D. G. Sturkie, K. H. Garren, J. T. Williamson, W. C. Gregory, C. Wilson, H. C. Harris, J. A. Yarbrough, and E. T. York Jr. 1951. The Peanut: The Unpredictable Legume A Symposium. 1st ed. Washington, DC: National Fertilizer Association. 333.

Askew, S.D. and J.W. Wilcut. 1999. Cost and weed management with herbicide programs in glyphosate-resistant cotton. Weed Tech. 13:308-313.

Balkcom, K., B. V. Ortiz, W. Goodman, and J.P. Fulton. 2010. Profitability of RTK autoguidance and its influence on peanut production. In Proceedings of the 10th International Conference of Precision Agriculture, Denver, Colorado: International Society of Precision Agriculture.

Batie, S. S. and R. G. Healy. 1983. Future of American agriculture. Sci. Am. 248: 45-53.

Bell, D. K. 1973. Effects of mechanical injury, fungi, and soul temperature on peanut seed decay in soil. Phytopathology 64:241-24.

Bowen K. L., A. K. Hagan, and J. R. Weeks. 1996. Soil-borne pests of peanut in growers' fields with different cropping histories in Alabama. Peanut Sci. 23: 36-42.

Brecke, B. J. and D. O. Stephenson. 2006. Weed management in single-vs. twin-row peanut(*Arachis hypogaea*). Weed Tech. 20: 368-376.

Brenneman, T.B., S. H. Baker, W. C. Johnson III, A. W. Johnson, and D. R. Sumner. 1999. Effects of tillage systems on peanut diseases, yield and fungicide performance in peanut-cotton rotation. Page 10 in Proceedings of the 22nd Annual Southern Conservation Tillage Conference for Sustainable Agriculture, Tifton, GA: Georgia Agriculture Experiment Station Special Publication 95.

Buchanan G. A., R. H. Crowley, J. E. Street and J. A. McGuire. 1980. Competition of sicklepod (*Cassia obtusifolia*) and redroot pigweed (*Amaranthus retroflexus*) with cotton (*Gossypium hirsutum*). Weed Sci. 28: 258-262.

Burnside, O.C. 1992. Rationale for developing herbicide-resistant crops. Weed Tech. 6: 621-625.

Carley, D. S., D. L. Jordan, B. B. Shew, T. B. Sutton, L. C. Dharmasri, and R. L. Brandenburg. 2009. Influence of digging date and fungicide program on canopy defoliation and pod yield of peanut (*Arachis hypogaea* L.). Peanut Sci. 36:77–84.

[CTIC] Conservation Technology Information Center. 2005. 2004 National crop residue management survey. http://www.ctic.purdue.edu/CTIC/CRM.html. Accessed April 21, 2006.

Culpepper A. S., T. L. Grey, W. K. Vencill, J. M. Kichler, T. M. Webster, S. M. Brown, A. C. York, J. W. Davis, and W. W. Hanna. 2006. Glyphosate-resistant Palmer amaranth (*Amaranthus palmeri*) confirmed in Georgia. Weed Sci. 54:620–626.

Derksen, D. A., G. P. Lafond, A. G. Thomas, H. A. Loeppky, and C. J. Swanton. 1993. Impact of agronomic practices on weed communities: Tillage Systems. Weed Sci. 41: 409-417.

Everman, W. J., S. B. Clewis, W. E. Thomas, I. C. Burke, and J. W. Wilcut .2008. Critical period of weed interference in peanut. Weed Tech. 22:63–67.

Faircloth, W. H., M. G. Patterson, C. D. Monks, and W. R. Goodman. 2001. Weed management programs for glyphosate-tolerant cotton (*Gossypium hirsutum*). Weed Tech. 15: 544-551.

Gardner, A. P., A. C. York, D. L. Jordan, and D. W. Monks. 2006. Management of annual grasses and Amaranthus spp. in glufosinate-resistant cotton. J. Cotton Sci. 10: 328–338.

Hagan, A. K., J. R. Weeks, K. L. Bowen, and L. Wells .2001. Influence of production practices on peanut disease and yield. Alabama Agricultural Experiment Station Bulletin 643. Available at: http://www.aaes.auburn.edu/comm/pubs/bulletins/bull643peanut.pdf.

Hook, J. E. (ed.). 1999. Proceedings of the 22nd Annual Southern Conservation Tillage Conference for Sustainable Agriculture. Tifton, GA. Georgia Agriculture Experiment Station Special Publication 95.

Johnson, III, W. C., J. A. Baldwin, and B. G. Mullinix, Jr. 2000. Winter fallow management of volunteer peanut (*Arachis hypogaea* L.) and cutleaf eveningprimrose (*Oenothera laciniata* Hill). Peanut Sci. 27: 67-70.

Kirkpatrick, T. L. and J.N. Sasser. 1984. Crop rotation and races of Meloidogyne incognita in cotton root-knot management. J. Nematol. 16: 323–328.

Locke, M. A., K.N. Reddy, and R.M. Zablotowicz . 2002. Weed management in conservation crop production systems. Weed Biol. Manag. 2: 123–132.

McWhorter, C.G. and J. R. Abernathy. 1992 Weeds of Cotton: Characterization and Control. Memphis, TN: The Cotton Foundation. 631 p.

Morgan, G. D., P. A. Baumann, and J. M. Chandler. 2001. Competitive impact of palmer amaranth (*Amaranthus palmeri*) on cotton (*Gossypium hirsutum*) development and yield. Weed Tech.15: 408-412.

Mullen, J. 2001. Southern blight, southern stem blight, white mold. The Plant Health Instructor. DOI: 10.1094/PHI-I-2001-0104-01.

Nandula, V. K. 2010. Glyphosate Resistance in Crops and Weeds: History, Development, and Management. 1st ed. Hoboken, NJ: John Wiley & Sons, Inc. 322 p.

Rodriguez-Kabana, R., H. Ivey, and P. A. Backman. 1987. Peanut-cotton rotations for the management of *Meloidogye arenaria*. J. Nematol.19: 484-486.

Rodriguez-Kabana, R., D. G. Robertson, L. Wells, C. F. Weaver, and P. S. King. 1991. Cotton as a rotation crop for the management of *Meloidogyne arenaria* and *Sclerotium rolfsii* in peanut. J. Nematol. 23: 652-657.

Rodriguez-Kabana, R. and G. H. Canullo. 1992. Cropping systems for the management of phytonematodes. Phytoparasitica 20: 211-224.

[TCE] Texas Cooperative Extension. 2007. Texas Peanut Production Guide. Texas Cooperative Extension, The Texas A&M University System. Available at: http://publications.tamu.edu/PEANUTS/PUB_peanuts_Texas%20Peanut%20Production%20Guide.pdf.

Thomas, R.J., R. E. Pettit, R. A. Taber, and B. L. Jones. 1983. Peanut peg strength: force required for pod detachment in relation to peg structure. Peanut Sci. 10:97-101.

Tillman, P. G., T. D. Northfield, R. F. Mizell, and T. C. Riddle. 2009. Spatiotemporal Patterns and Dispersal of Stink Bugs (Heteroptera: Pentatomidae) in Peanut-Cotton Farmscapes. Environ. Entomol. 38:1038-1052.

Wehtje G., R. H. Walker, M. G. Patterson and J. A. McGuire. 1984. Influence of twin rows on yield and weed control in peanuts. Peanut Sci. 11: 88-91.

Windham W. R., C.V.K. Kandala, J. Sundaram, and R C. Nuti. 2010. Determination of peanut pod maturity by near-infrared reflectance spectroscopy. Transactions of the ASABE. 53: 491-495.

Wright F. S. and D. M. Porter. 1991. Digging date and conservational tillage influence on peanut production. Peanut Sc. 18: 72-75.

York, A. C, D. L. Jordan, and J.W. Wilcut. 1994. Peanut control in rotational crops. Peanut Sci. 21:40-43.

Figure 1. Control of volunteer peanut following postemergence applications of glyphosate and glufosinate herbicides at cotton's 2-leaf stage at Wiregrass Research and Extension Center, Headland, AL.[a][b]
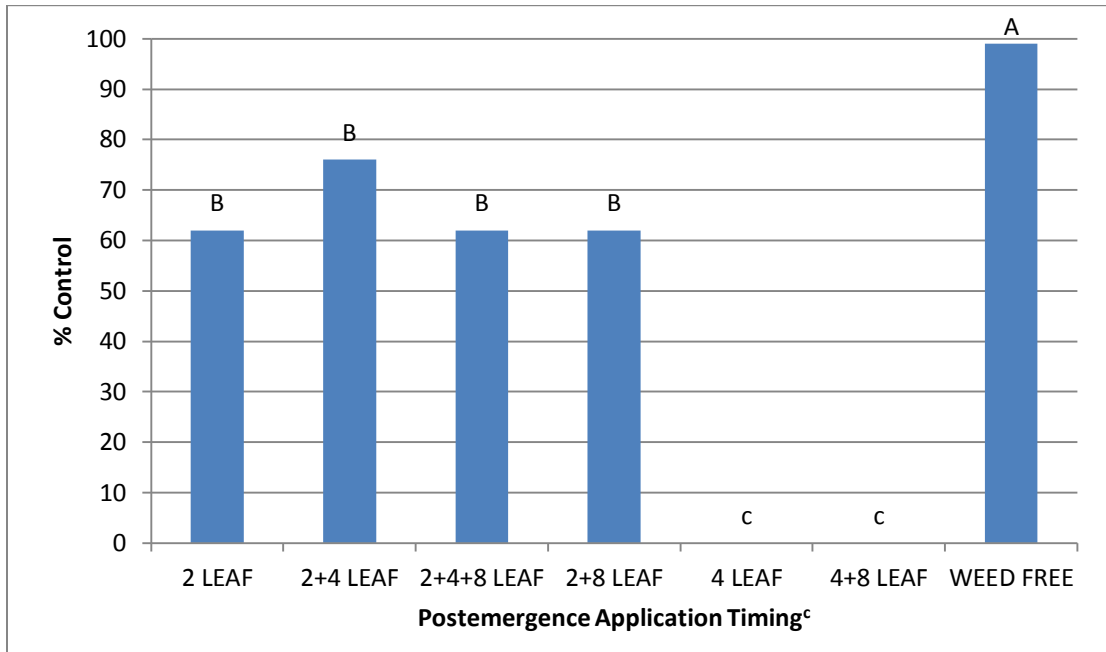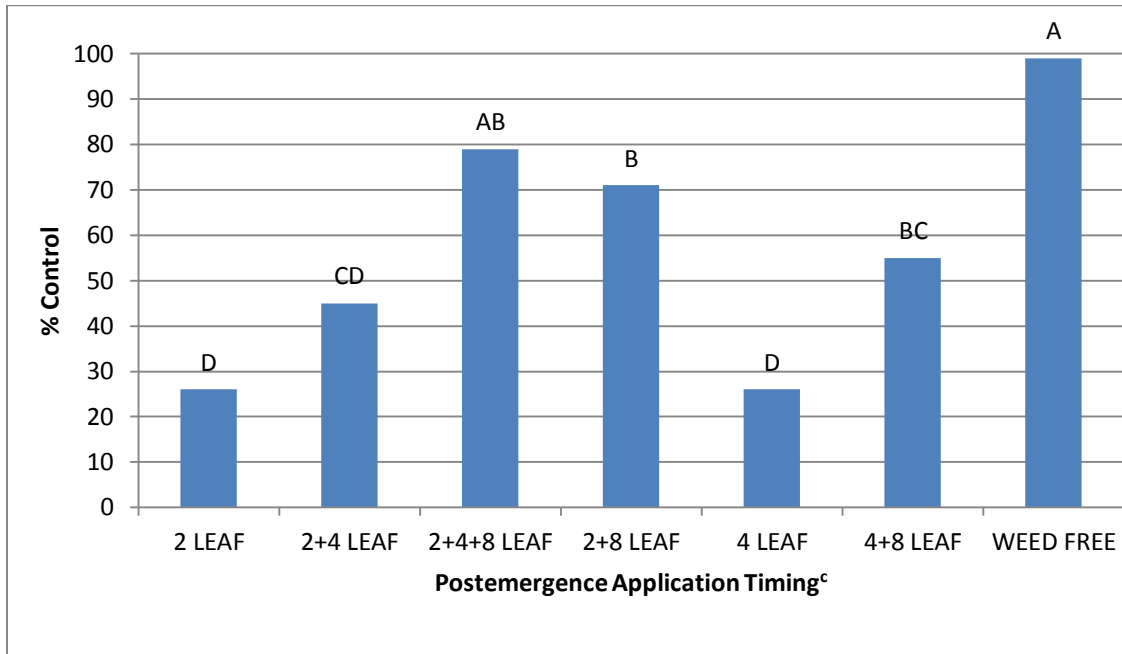

[a] Ratings reflect control 7 DAT of 2-leaf cotton stage. Applications for 4-leaf and 4+8-leaf not applied at time of rating.
[b] All treatments received 1.8525 kg a.i. ha^{-1} of pendimethalin + 0.105 kg a.i. ha^{-1} of fomesafen as a pre-emergent and 2.47 kg a.i. ha^{-1} of prometryn + 4.94 kg a.i. ha^{-1} of MSMA as post-directed spray.
[c] Either 2.47 kg a.i. ha^{-1} glyphosate or 1.0375 kg a.i. ha^{-1} glufosinate was sprayed at 2-, 4-, or 2+ 4-leaf. Trifloxysulfuron-sodium was applied at 0.011362 kg a.i. ha^{-1} at the cotton's 8-leaf stage.

Figure 2. Control of various grass species following postemergence herbicide at cotton's 2-leaf stage at Wiregrass Research and Extension Center, Headland, AL.[a][b]

[a] Ratings reflect control 7 DAT of 2-leaf cotton stage. Applications of 4-leaf and 4+8-leaf not applied at time of rating.
[b] All treatments received 1.8525 kg a.i. ha^{-1} of pendimethalin + 0.105 kg a.i. ha^{-1} of fomesafen as a pre-emergent and 2.47 kg a.i. ha^{-1} of prometryn + 4.94 kg a.i. ha^{-1} of MSMA as post-directed spray.
[c] Either 2.47 kg a.i. ha^{-1} glyphosate or 1.0375 kg a.i. ha^{-1} glufosinate was sprayed at 2-, 4-, or 2+ 4-leaf. Trifloxysulfuron-sodium was applied at 0.011362 kg a.i. ha^{-1} at the cotton's 8-leaf stage.

Figure 3. Control of volunteer peanut following postemergence applications of glyphosate and glufosinate herbicides at cotton's 4-leaf stage at Wiregrass Research and Extension Center, Headland, AL.[a][b]
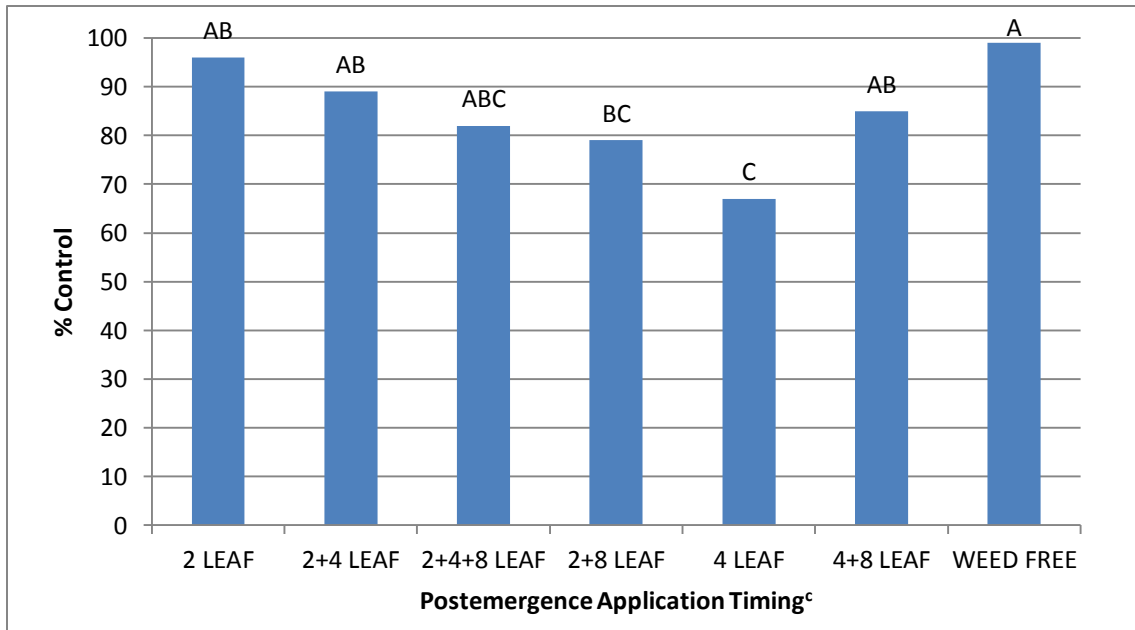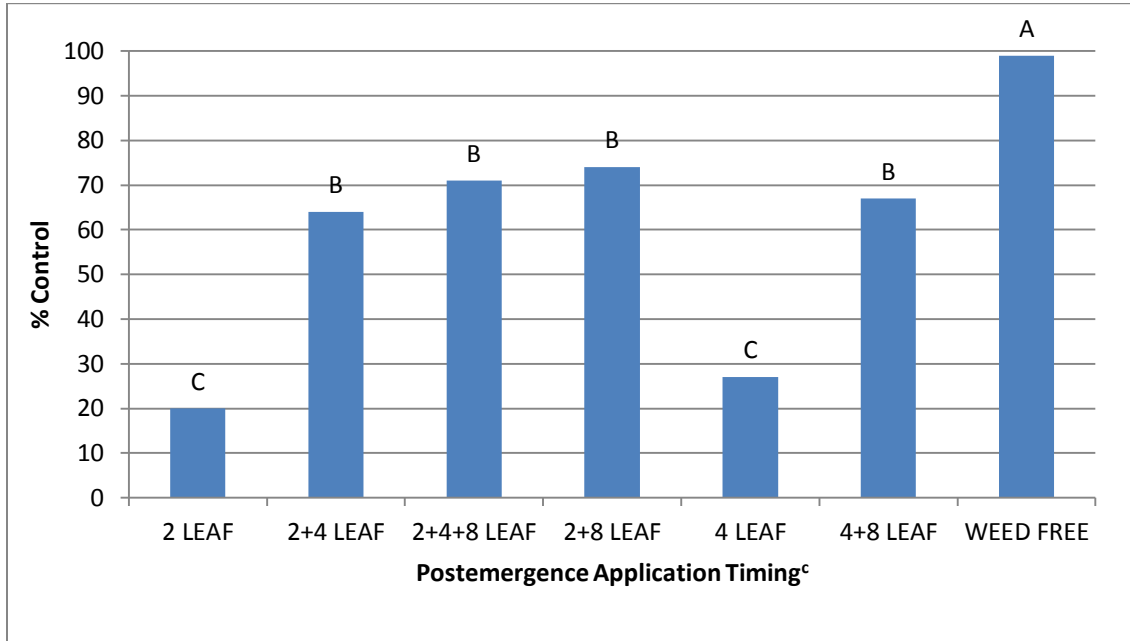

[a] Ratings reflect control 10 DAT of 4-leaf cotton.
[b] All treatments received 1.8525 kg a.i. ha^{-1} of pendimethalin + 0.105 kg a.i. ha^{-1} of fomesafen as a pre-emergent and 2.47 kg a.i. ha^{-1} of prometryn + 4.94 kg a.i. ha^{-1} of MSMA as post-directed spray.
[c] Either 2.47 kg a.i. ha^{-1} glyphosate or 1.0375 kg a.i. ha^{-1} glufosinate was sprayed at 2-, 4-, or 2+ 4-leaf. Trifloxysulfuron-sodium was applied at 0.011362 kg a.i. ha^{-1} at the cotton's 8-leaf stage.

Figure 4. Control of various grass species following postemergence applications of glyphosate and glufosinate herbicides at cotton's 4-leaf stage at Wiregrass Research and Extension Center, Headland, AL.[a]

[a] Ratings reflect control 10 DAT of 4-leaf cotton.
[b] All treatments received 1.8525 kg a.i. ha^{-1} of pendimethalin + 0.105 kg a.i. ha^{-1} of fomesafen as a pre-emergent and 2.47 kg a.i. ha^{-1} of prometryn + 4.94 kg a.i. ha^{-1} of MSMA as post-directed spray.
[c] Either 2.47 kg a.i. ha^{-1} glyphosate or 1.0375 kg a.i. ha^{-1} glufosinate was sprayed at 2-, 4-, or 2+ 4-leaf. Trifloxysulfuron-sodium was applied at 0.011362 kg a.i. ha^{-1} at the cotton's 8-leaf stage.

Figure 5. Control of volunteer peanut following postemergence herbicide at cotton's 8-leaf stage at Wiregrass Research and Extension Center, Headland, AL.[a]
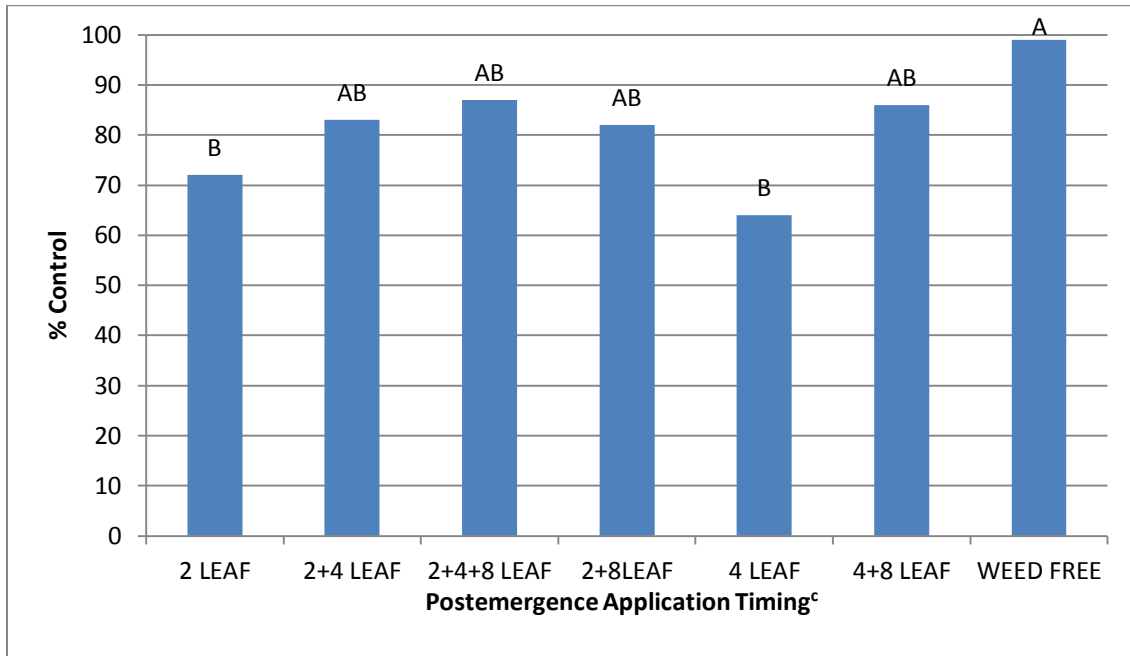

[a] Ratings reflect control 31 DAT of 8-leaf cotton.

[b] All treatments received 1.8525 kg a.i. ha^{-1} of pendimethalin + 0.105 kg a.i. ha^{-1} of fomesafen as a pre-emergent and 2.47 kg a.i. ha^{-1} of prometryn + 4.94 kg a.i. ha^{-1} of MSMA as post-directed spray.

[c] Either 2.47 kg a.i. ha^{-1} glyphosate or 1.0375 kg a.i. ha^{-1} glufosinate was sprayed at 2-, 4-, or 2+ 4-leaf. Trifloxysulfuron-sodium was applied at 0.011362 kg a.i. ha^{-1} at the cotton's 8-leaf stage.

Figure 6. Control of various grass species following postemergence herbicide at cotton's 8-leaf stage at Wiregrass Research and Extension Center, Headland, AL.[a]
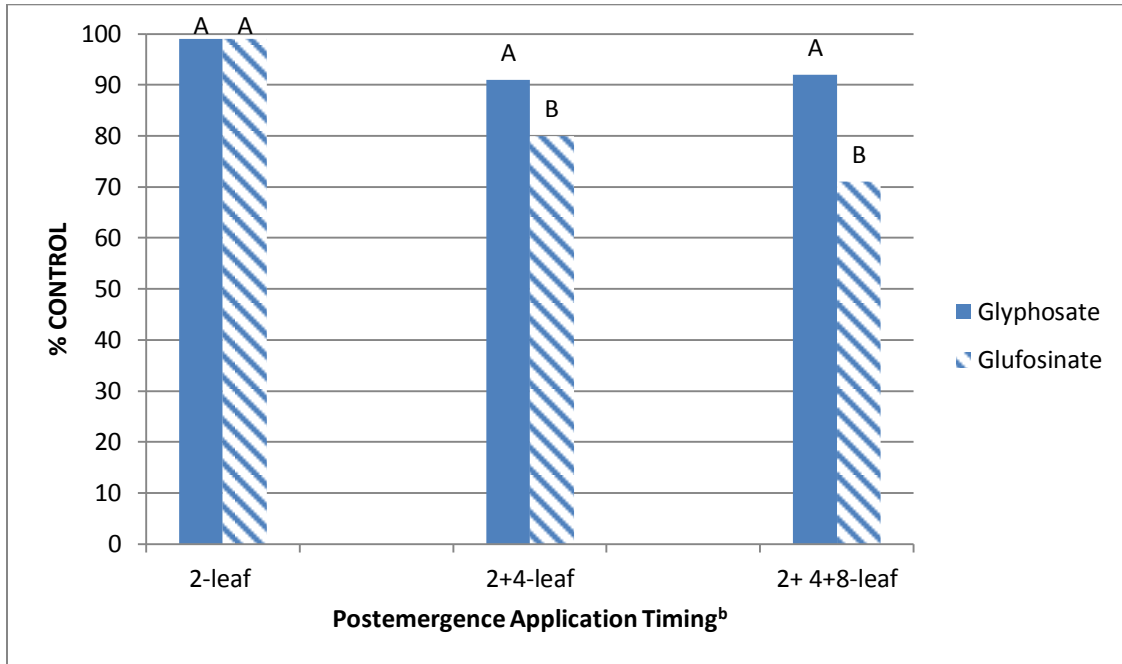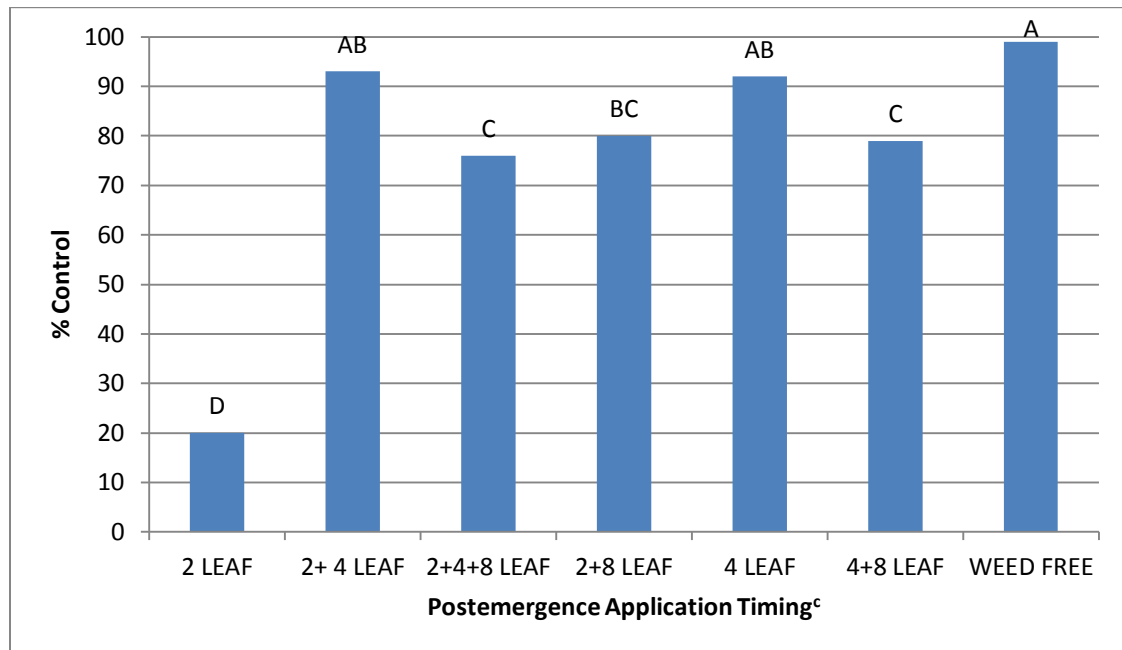

[a] Ratings reflect control 31 DAT of 8-leaf cotton.
[b] All treatments received 1.8525 kg a.i. ha^{-1} of pendimethalin + 0.105 kg a.i. ha^{-1} of fomesafen as a pre-emergent and 2.47 kg a.i. ha^{-1} of prometryn + 4.94 kg a.i. ha^{-1} of MSMA as post-directed spray.
[c] Either 2.47 kg a.i. ha^{-1} glyphosate or 1.0375 kg a.i. ha^{-1} glufosinate was sprayed at 2-, 4-, or 2+ 4-leaf. Trifloxysulfuron-sodium was applied at 0.011362 kg a.i. ha^{-1} at the cotton's 8-leaf stage.

Figure 7. Comparing glyphosate and glufosinate control of various grass species at Wiregrass Research and Extension Center, Headland, AL. [a]

[a]All treatments received 1.8525 kg a.i. ha^{-1} of pendimethalin + 0.105 kg a.i. ha^{-1} of fomesafen as a pre-emergent and 2.47 kg a.i. ha^{-1} of prometryn + 4.94 kg a.i. ha^{-1} of MSMA as post-directed spray.
[b]Either 2.47 kg a.i. ha^{-1} glyphosate or 1.0375 kg a.i. ha^{-1} glufosinate was sprayed at 2-, 4-, or 2+ 4-leaf. Trifloxysulfuron-sodium was applied at 0.011362 kg a.i. ha^{-1} at the cotton's 8-leaf stage.

Figure 8. Control of volunteer peanut following postemergence herbicide at cotton's 8-leaf stage at Gulf Coast Research and Extension Center, Fairhope, AL.[a]
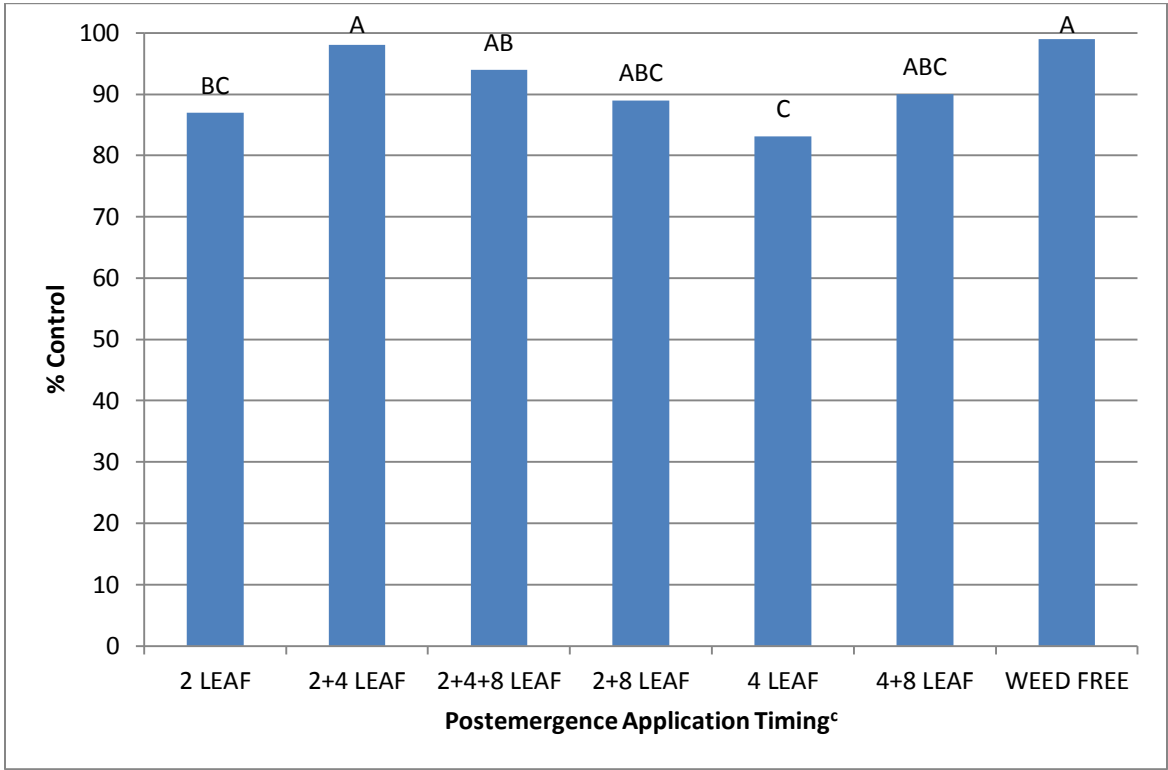

[a.] Ratings reflect control 31 DAT of 8-leaf cotton.
[b]All treatments received 1.8525 kg a.i. ha^{-1} of pendimethalin + 0.105 kg a.i. ha^{-1} of fomesafen as a pre-emergent and 2.47 kg a.i. ha^{-1} of prometryn + 4.94 kg a.i. ha^{-1} of MSMA as post-directed spray.
[c] Either 2.47 kg a.i. ha^{-1} glyphosate or 1.0375 kg a.i. ha^{-1} glufosinate was sprayed at 2-, 4-, or 2+ 4-leaf. Trifloxysulfuron-sodium was applied at 0.011362 kg a.i. ha^{-1} at the cotton's 8-leaf stage.

Figure 9. Control of various grass species following postemergence herbicide at cotton's 8-leaf stage at Gulf Coast Research and Extension Center, Fairhope, AL.[a]
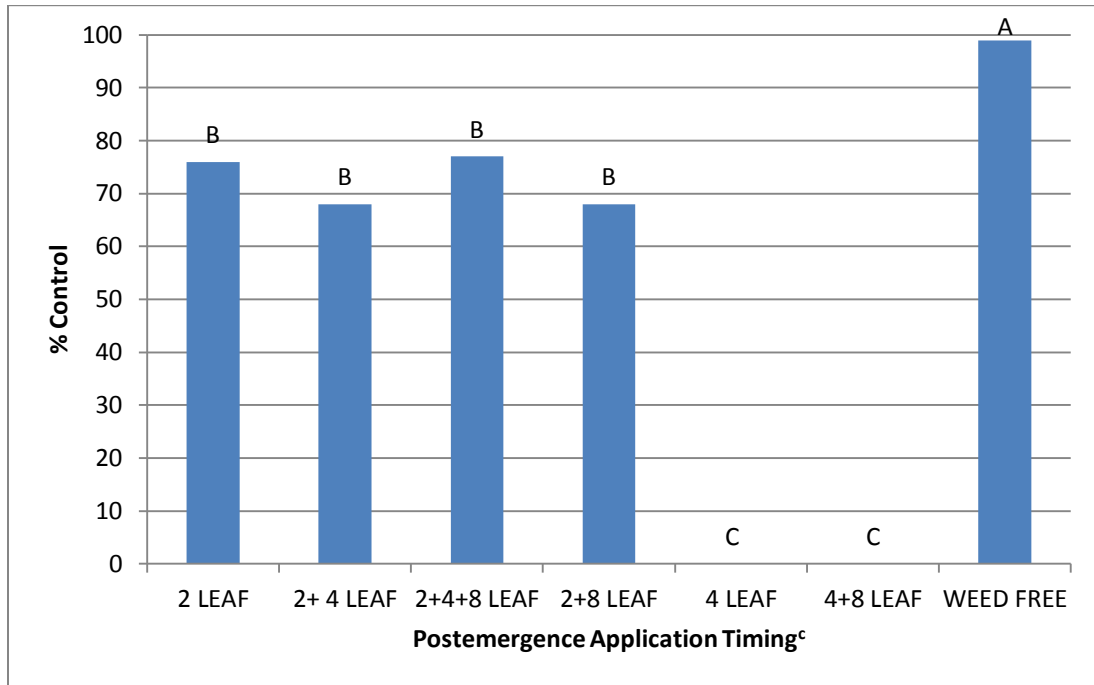

[a]Ratings reflect control 31 DAT of 8-leaf cotton.
[b]All treatments received 1.8525 kg a.i. ha^{-1} of pendimethalin + 0.105 kg a.i. ha^{-1} of fomesafen as a pre-emergent and 2.47 kg a.i. ha^{-1} of prometryn + 4.94 kg a.i. ha^{-1} of MSMA as post-directed spray.
[c]Either 2.47 kg a.i. ha^{-1} glyphosate or 1.0375 kg a.i. ha^{-1} glufosinate was sprayed at 2-, 4-, or 2+ 4-leaf. Trifloxysulfuron-sodium was applied at 0.011362 kg a.i. ha^{-1} at the cotton's 8-leaf stage.

Figure 10. Control of volunteer peanut following postemergence applications of glyphosate and glufosinate herbicides at cotton's 2-leaf stage at Gulf Coast Research and Extension Center, Fairhope, AL.[a]
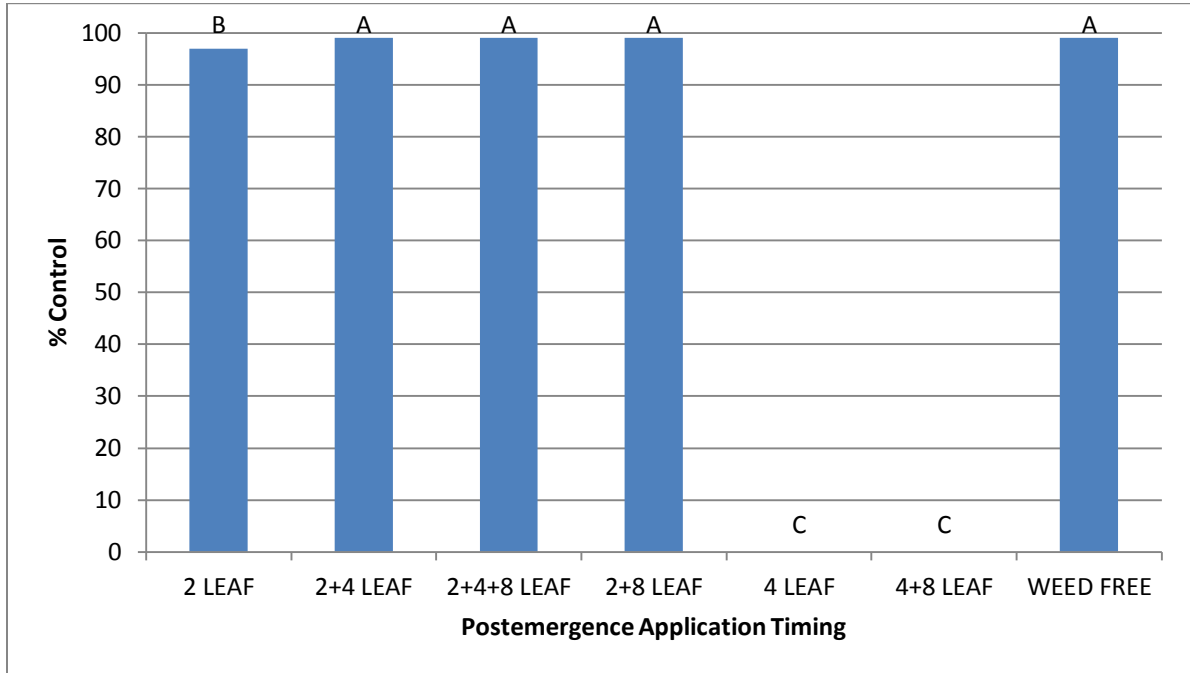

[a] Ratings reflect control 7 DAT of 2-leaf cotton stage. Applications of 4-leaf and 4+8-leaf not applied at time of rating.
[b] All treatments received 1.8525 kg a.i. ha^{-1} of pendimethalin + 0.105 kg a.i. ha^{-1} of fomesafen as a pre-emergent and 2.47 kg a.i. ha^{-1} of prometryn + 4.94 kg a.i. ha^{-1} of MSMA as post-directed spray.
[c] Either 2.47 kg a.i. ha^{-1} glyphosate or 1.0375 kg a.i. ha^{-1} glufosinate was sprayed at 2-, 4-, or 2+ 4-leaf. Trifloxysulfuron-sodium was applied at 0.011362 kg a.i. ha^{-1} at the cotton's 8-leaf stage.

Figure 11. Control of various grass species following postemergence herbicide at cotton's 2-leaf stage at Gulf Coast Research and Extension Center, Fairhope, AL.[a]
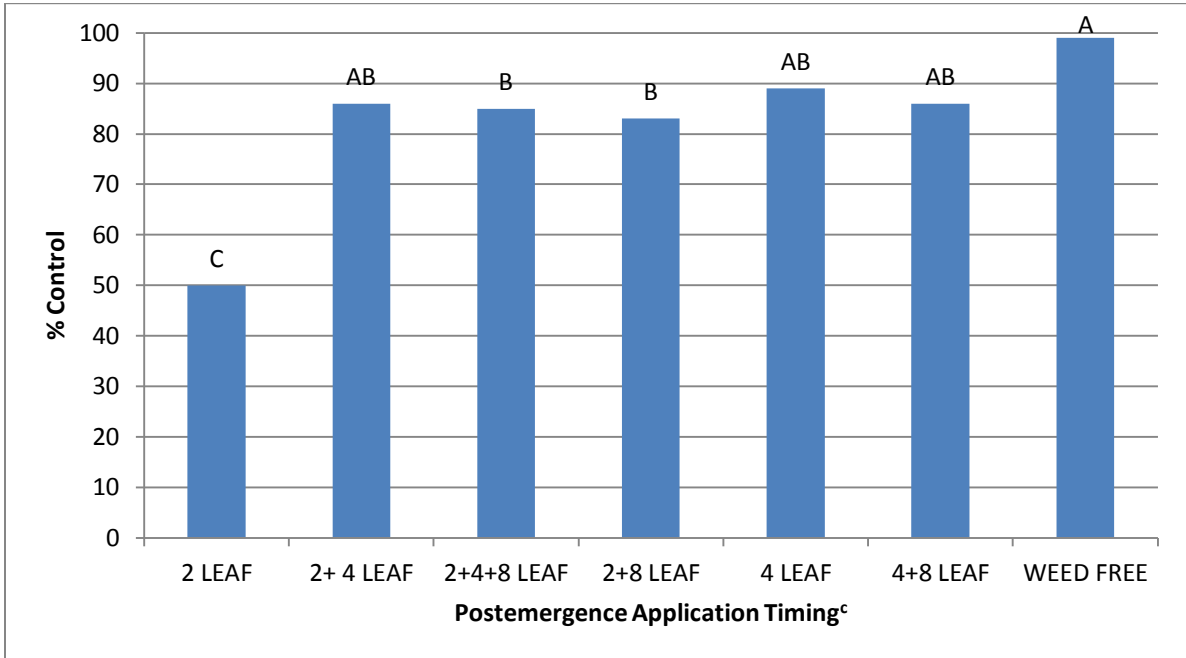

[a] Ratings reflect control 7 DAT of 2-leaf cotton stage. Applications of 4-leaf and 4+8-leaf not applied at time of rating.
[b] All treatments received 1.8525 kg a.i. ha^{-1} of pendimethalin + 0.105 kg a.i. ha^{-1} of fomesafen as a pre-emergent and 2.47 kg a.i. ha^{-1} of prometryn + 4.94 kg a.i. ha^{-1} of MSMA as post-directed spray.
[c] Either 2.47 kg a.i. ha^{-1} glyphosate or 1.0375 kg a.i. ha^{-1} glufosinate was sprayed at 2-, 4-, or 2+ 4-leaf. Trifloxysulfuron-sodium was applied at 0.011362 kg a.i. ha^{-1} at the cotton's 8-leaf stage.

Figure 12. Control of volunteer peanut following postemergence applications of glyphosate and glufosinate herbicides at cotton's 4-leaf stage at Gulf Coast Research and Extension Center, Fairhope, AL.[a]
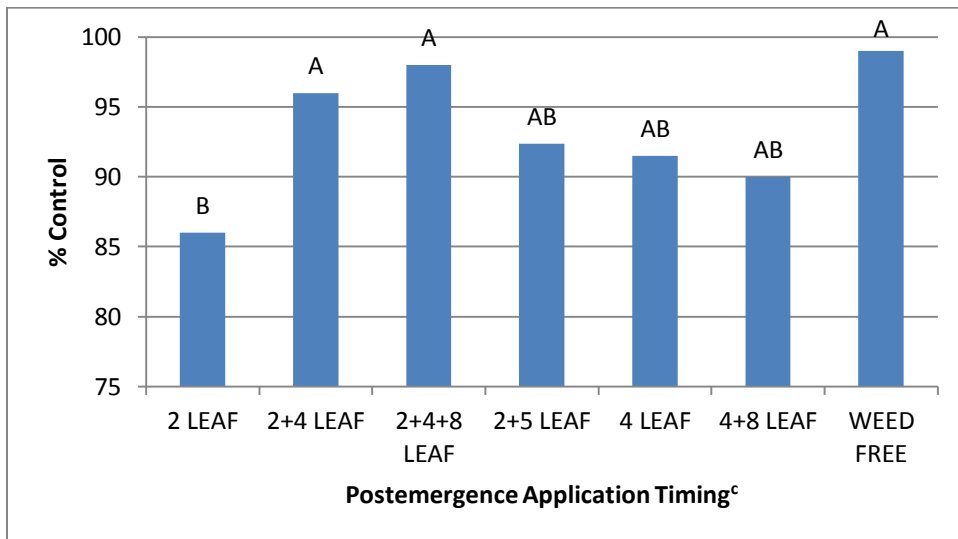

[a] Ratings reflect control 10 DAT of 4-leaf cotton.

[b] All treatments received 1.8525 kg a.i. ha^{-1} of pendimethalin + 0.105 kg a.i. ha^{-1} of fomesafen as a pre-emergent and 2.47 kg a.i. ha^{-1} of prometryn + 4.94 kg a.i. ha^{-1} of MSMA as post-directed spray.

[c] Either 2.47 kg a.i. ha^{-1} glyphosate or 1.0375 kg a.i. ha^{-1} glufosinate was sprayed at 2-, 4-, or 2+ 4-leaf. Trifloxysulfuron-sodium was applied at 0.011362 kg a.i. ha^{-1} at the cotton's 8-leaf stage.

Figure 13. Control of various grass species following postemergence applications of glyphosate and glufosinate herbicides at cotton's 4-leaf stage at Gulf Coast Research and Extension Center, Fairhope, AL.[a][b]
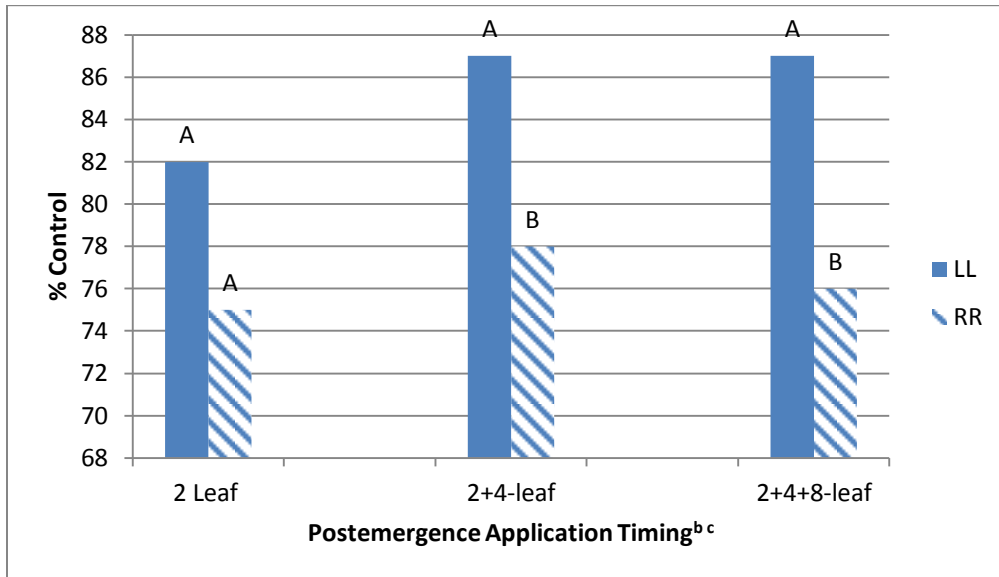

[a] Ratings reflect control 10 DAT of 4-leaf cotton.
[b] All treatments received 1.8525 kg a.i. ha^{-1} of pendimethalin + 0.105 kg a.i. ha^{-1} of fomesafen as a pre-emergent and 2.47 kg a.i. ha^{-1} of prometryn + 4.94 kg a.i. ha^{-1} of MSMA as post-directed spray.
[c] Either 2.47 kg a.i. ha^{-1} glyphosate or 1.0375 kg a.i. ha^{-1} glufosinate was sprayed at 2-, 4-, or 2+ 4-leaf. Trifloxysulfuron-sodium was applied at 0.011362 kg a.i. ha^{-1} at the cotton's 8-leaf stage.

Figure 14. Comparing glyphosate and glufosinate control of volunteer peanut at Gulf Coast Research and Extension Center, Fairhope, AL[a]
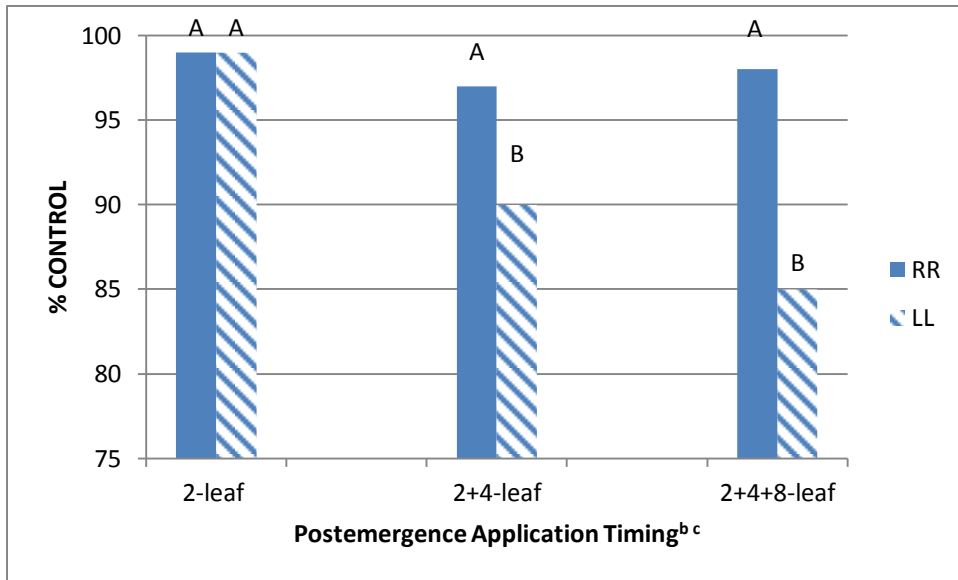

[a]All treatments received 1.8525 kg a.i. ha^{-1} of pendimethalin + 0.105 kg a.i. ha^{-1} of fomesafen as a pre-emergent and 2.47 kg a.i. ha^{-1} of prometryn + 4.94 kg a.i. ha^{-1} of MSMA as post-directed spray.
[b] Either 2.47 kg a.i. ha^{-1} glyphosate or 1.0375 kg a.i. ha^{-1} glufosinate was sprayed at 2-, 4-, or 2+ 4-leaf. Trifloxysulfuron-sodium was applied at 0.011362 kg a.i. ha^{-1} at the cotton's 8-leaf stage.
[c]Ratings reflect control 31 DAT of 8-leaf cotton.

Figure 15. Comparing glyphosate and glufosinate control of various grass species at Gulf Coast Research and Extension Center, Fairhope, AL [a]
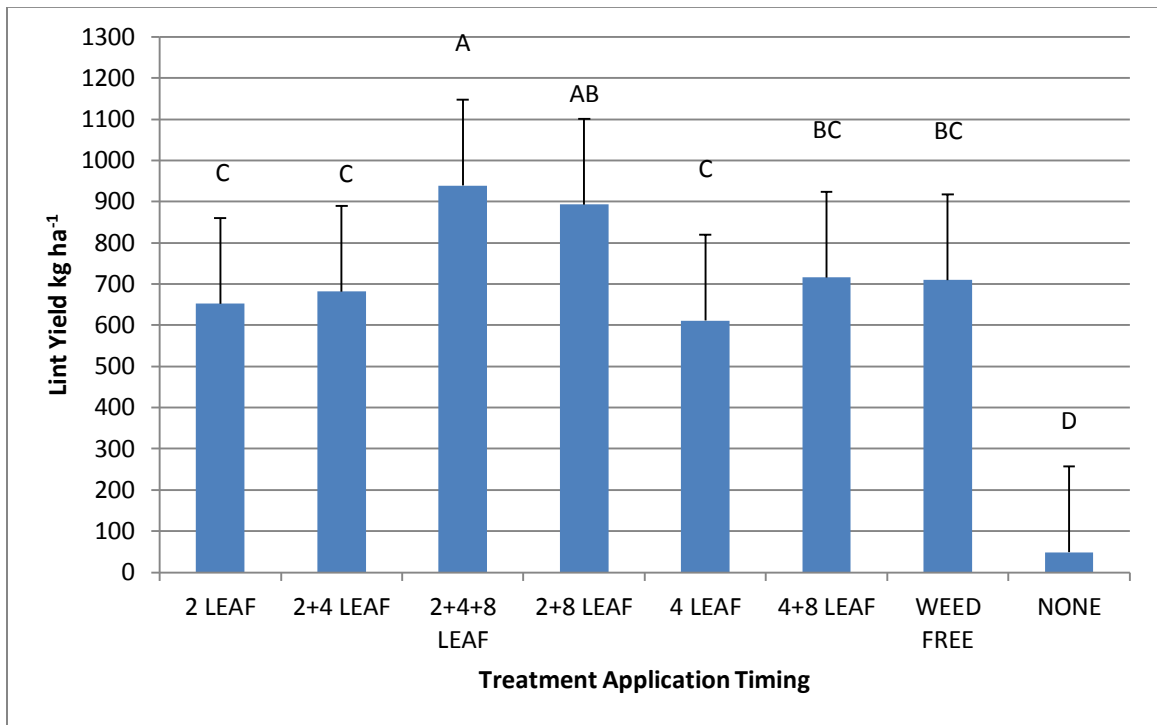

[a]All treatments received 1.8525 kg a.i. ha^{-1} of pendimethalin + 0.105 kg a.i. ha^{-1} of fomesafen as a pre-emergent and 2.47 kg a.i. ha^{-1} of prometryn + 4.94 kg a.i. ha^{-1} of MSMA as post-directed spray.
[b] Either 2.47 kg a.i. ha^{-1} glyphosate or 1.0375 kg a.i. ha^{-1} glufosinate was sprayed at 2-, 4-, or 2+ 4-leaf. Trifloxysulfuron-sodium was applied at 0.011362 kg a.i. ha^{-1} at the cotton's 8-leaf stage.
[c]Ratings reflect control 31 DAT of 8-leaf cotton.

Figure 16. Cotton lint yield (kg ha^{-1}) at Wiregrass Research and Extension Center, Headland, AL.[a,b,c]

[a] All treatments received 1.8525 kg a.i. ha^{-1} of pendimethalin + 0.105 kg a.i. ha^{-1} of fomesafen as a pre-emergent and 2.47lbs kg a.i. ha^{-1} of prometryn + 4.94 kg a.i. ha^{-1} of MSMA as post-directed spray.
[b] Either 2.47 kg a.i. ha^{-1} glyphosate or 1.0375 kg a.i. ha^{-1} glufosinate was sprayed at 2, 4, or 2& 4-leaf .
[c] Trifloxysulfuron-sodium was applied at 0.011362 kg a.i. ha^{-1} at the cotton's 8-leaf stage.

Figure 17. Comparison of RoundUp Ready (RR) yield vs. LibertyLink (LL) at Wiregrass Research and Extension Center, Headland, AL.
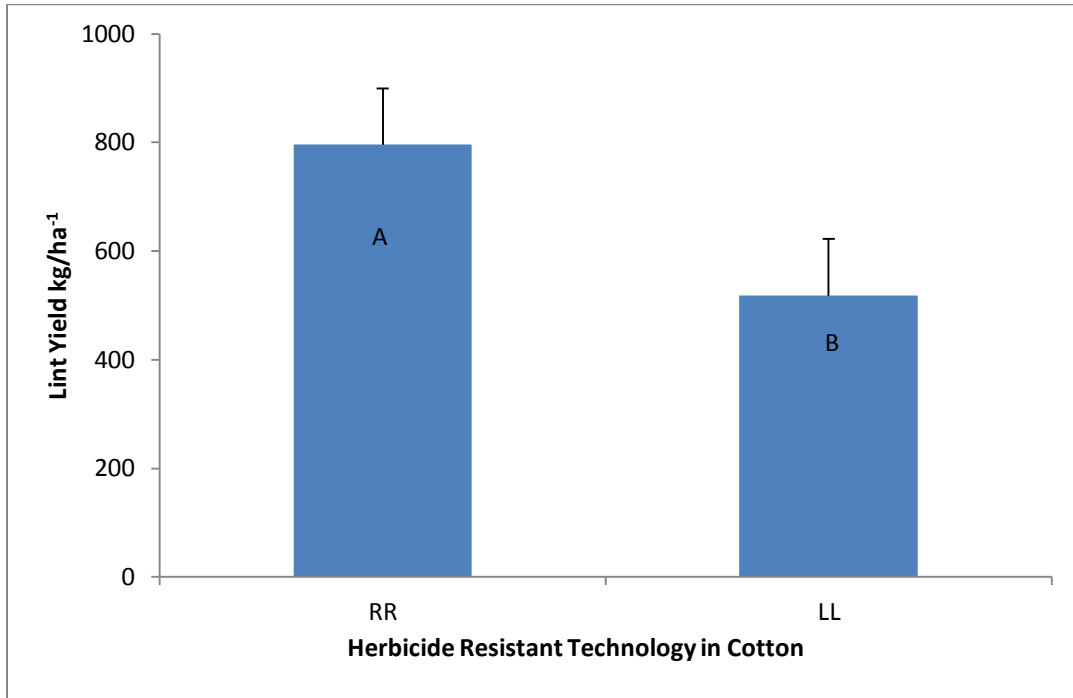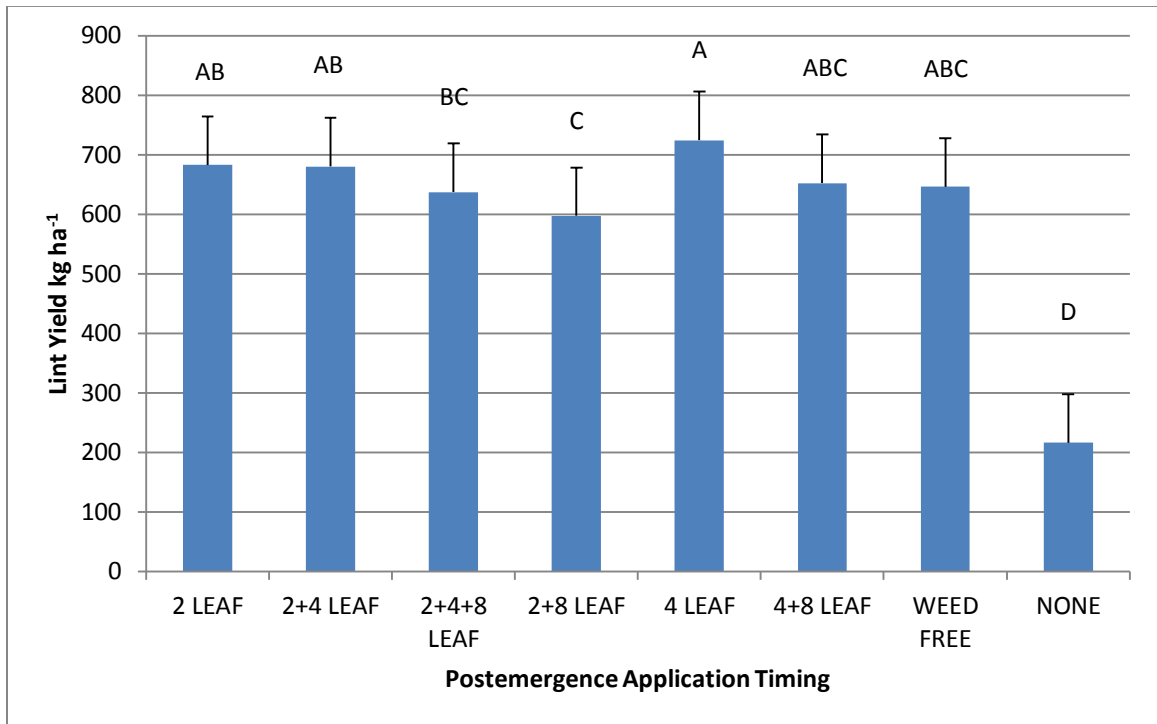
Figure 18. Cotton lint yield (kg ha^{-1}) at Gulf Coast Research and Extension Center, Fairhope, AL.[a,b,c]

[a] All treatments received 1.8525 kg a.i. ha^{-1} of pendimethalin + 0.105 kg a.i. ha^{-1} of fomesafen as a pre-emergent and 2.47lbs kg a.i. ha^{-1} of prometryn + 4.94 kg a.i. ha^{-1} of MSMA as post-directed spray.
[b] Either 2.47 kg a.i. ha^{-1} glyphosate or 1.0375 kg a.i. ha^{-1} glufosinate was sprayed at 2, 4, or 2& 4-leaf .
[c] Trifloxysulfuron-sodium was applied at 0.011362 kg a.i. ha^{-1} at the cotton's 8-leaf stage.