ROUNDUP READY FLEX® COTTON YIELD AND WEED COMPOSITION AFTER SIX CONTINUOUS YEARS OF THE SAME SIXTEEN HERBICIDE TREATMENTS

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ROUNDUP READY FLEX® COTTON YIELD AND

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AFTER SIX CONTINUOUS YEARS OF THE

SAME SIXTEEN HERBICIDE TREATMENTS

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PREFACE

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ROUNDUP READY FLEX® COTTON YIELD AND WEED COMPOSITION AFTER SIX CONTINUOUS YEARS OF THE SAME SIXTEEN HERBICIDE TREATMENTS

Abstract: An experiment with Roundup Ready Flex® cotton was started in 2006 at the South Central Research Station near Chickasha, OK. The purpose of this research was to measure weed species composition and cotton yield in a continuous long-term experiment comparing glyphosate and conventional herbicide treatments. The experimental design was a randomized complete block design with 16 herbicide treatments replicated four times. Plot size was 12 rows (1.0 m per row spacing) X 30.5 m long. All weed counts and harvest data were collected from the four center rows of each plot. All herbicides used were applied at the labeled rates. The weeds that were most common in the experiment were johnsongrass, Palmer amaranth, and common cocklebur, and on drier years, silverleaf nightshade. Weed counts were taken after all treatments were applied. Cotton yield data were collected on all plots that were harvestable, except in 2011, no plots were harvested due to severe drought. Herbicides which were used in various combinations from 2006 through 2009 included trifluralin (PPI), prometryn (PRE), pyrithiobac (PRE and POST), glyphosate (POST), metolachlor (POST), and an untreated check. In 2010 and 2011, the entire experimental area was treated with a PPI application of trifluralin, and then a POST 1 application of glyphosate (various Monsanto formulations) on an as needed basis followed by a POST 2 and POST 3 application of

glyphosate. Conventional herbicides applications from 2006 through 2009 did not control common cocklebur nor Palmer amaranth; therefore, those plots were not harvested. Data collected from 2006 through 2009 showed that eight of the 16 treatments were not harvested due to high populations of common cocklebur and Palmer amaranth. In 2010 the best management practices were trifluralin (PPI) followed by glyphosate (POST 2 and POST 3) and trifluralin (PPI) followed by glyphosate (POST 1, POST 2, and POST 3) provided effective weed control and all plots were harvested. The best management practices selected in 2010 successfully controlled the targeted weeds and allowed for a uniform cotton lint yield over the entire experiment area for the first time in experiment's history. Data from 2011 shows that cotton did not canopy over exposed soil in the row due to lack of water and abnormally hot and dry conditions; therefore there was noticeable increase in silverleaf nightshade in both of the treatments.

Nomenclature: Upland cotton, *Gossypium hirsutum* (L.) GOSHI; Palmer amaranth, *Amaranthus palmeri* S. Wats. AMAPA; common cocklebur, *Xanthium strumarium* (L.) XANST; johnsongrass, *Sorghum halepense* Pers. SORGA; silverleaf nightshade, *Solanum elaeagnifolium* Cav. SOLEL; ivyleaf morningglory, *Ipomoea hederacea* Jacq. IPOHE; pitted morningglory, *Ipomoea lacunose* (L.) IPOLA; devil's-claw, *Proboscidea louisanica*, (P. Mill) Thellung PROLO; yellow nutsedge, *Cyperus esculentus* (L.) CYPES; Texas panicum, *Panicum texanum* PANTE; large crabgrass, *Digitaria sanguinalis* (L). DIGSA; Isopropylamine salt of N- (phosphonomethyl) glycine; a,a,a-trifluoro-2,6-dinitro-N, N-dipropyl-p-toluidine, sodium 2-chloro-6-(4,6-

dimethoxypyrimidin-2-ylthio)benzoate, N2,N4-di-isopropyl-6-methylthio-1,3,5-triazine-2,4-diyldiamine [6], Quizalofop-ethyl, 2-chloro-N-(2-ethyl-6-methylphenyl)-N-(2-methoxy-1-methylenthyl) acetamide.

CHAPTER I

INTRODUCTION

Due to its unique growth and development, the cotton plant is greatly influenced by weeds, resulting in a $300 million crop loss per year (Abernathy and McWhorter,1992). This would convert to a $700 million crop loss when the experiment was started in 2006. This statement has made cotton producers aware of the amount of money that is lost with every infestation of weeds in their cotton fields. Weed control in cotton requires intense and punctual crop management skills. It is not surprising that weeds are such a significant problem in the production of cotton. Cotton emerges and grows slowly during the first few weeks after planting. This is especially true during cool weather or under other stressful weather conditions. It is only after the cotton plant has become well established and soil temperatures are greater than 24°C (75°F) that the plant becomes competitive. During this entire early period of establishment, usually the first 9 to 10 wk after planting, control of weeds is a necessity for orderly development of cotton (Buchanan & Burns, 1970).

One of the ways to control weeds in cotton was the introduction of herbicide-tolerant crops. Monsanto's 1st generation Roundup-Ready® cotton varieties were introduced to cotton producers in 1995. These early glyphosate-tolerant cotton varieties allowed cotton producers to apply an over-the-top glyphosate application post fifth-leaf growth stage to Monsanto's 1st generation Roundup-Ready® cotton varieties. Glyphosate is a foliar-applied, broad spectrum, non-selective, POST herbicide. It is highly effective in controlling a wide range of annual and perennial grasses and broadleaf weeds. With this glyphosate-tolerant technology, cotton producers were able to apply glyphosate on an as needed basis for weed management as long as they did not exceed the annual label restrictions. Cotton producers are now able to limit cultivation to get their desired weed control, assuming weed resistance is not an issue.

In 2006, the 2nd generation of Roundup Ready® cotton, termed Roundup Ready Flex® cotton, was made commercially available. This new development allows cotton producers to make glyphosate applications over-the-top regardless of crop growth stage. This would place less reliance on specialized spray equipment intended to reduce herbicide-plant contact and allows the use of larger, faster-moving equipment. In addition, this affords the ability to reduce the number of applications trips through the field by co-applying insecticides, plant growth regulators or micronutrient fertilizers with glyphosate in over-the-top applications (Miller, Stewart, 2006). Producers could apply anytime from PRE to 7 d before harvest to fit their weed management practices. Glyphosate does not have any residual soil activity, so producers need multiple applications throughout the growing season to get their desired weed control as long as they don't exceed labeled annual application rates, and herbicide resistance is not an issue. Mechanical methods of weed control are important in cotton production to reduce the chance of emergence of herbicide resistant weeds.

Perennial weeds such as silverleaf nightshade and johnsongrass, and annual weeds such as Palmer amaranth and common cocklebur are some of the most problematic weeds in cotton production. A weed survey study conducted in 2005 by D. S. Murray and C.R. Medlin concluded that five of the top 10 most common weeds found in Oklahoma upland cotton were *Amaranthus* spp., *Morningglory* spp., red-sprangletop [*Leptochloa filiformis* (Lam) Beav], large crabgrass, and Texas panicum. Five of the top 10 most troublesome weeds found in Oklahoma upland cotton were annual morningglories, silverleaf nightshade, pigweeds, red sprangletop, and yellow nutsedge (Webster 2005).

In the United States, approximately 30 plant species infesting cotton fields are economically important weeds (Holm et al. 1977). Approximately 80% of the losses from weeds in cotton can be attributed to 10 weed species (Table 1).

Silverleaf nightshade reduces the yields of cotton, grain sorghum [*Sorghum bicolor* (L.) Moench], alfalfa [*Medicago sativa* (L.)], and cereal grains through competition and harvest interference. Under semi-arid conditions, cotton yields have been reduced by 75% (Smith et al,1973). Weed management systems in cotton often include a combination of soil-applied herbicides, timely applications of POST over-the-top herbicides, POST directed herbicides, and mechanical forms of control.

The nation's cotton producers also reported a significant acreage increase from 2010. According to the report, 5.5 million ha have been planted to cotton in 2011, up 25 percent from 2010 (USDA-NASS). With cotton acreages increasing, weed control and weed management techniques are important as ever.

Since cotton production is such a complex and costly crop to produce, producers need to minimize costs. Every chemical application costs a producer time and money, which are both limited resources.

Weeds compete (both intraspecifically and interspecifically) with agronomic crops for light, water, nutrients, and space. With a weed that produces as many seeds as Palmer amaranth, cotton producers need to control the spread of weeds in their fields and surrounding areas to avoid weed seed bank build-up. Total seed production of Palmer amaranth in the fall ranged from 200,000 to 600,000 seeds/plant for the March through June plantings, and 115,000 to 80,000 seed/plant for the July through September plantings (Kelly, et al., 1987). Weed control in cotton is essential to optimize fiber yield and quality. Cotton has a weed free requirement of approximately 8 wk to produce maximum yields (Wilcut, et al., 2003).

The objectives of this experiment were to measure the effectiveness of herbicide treatments on weed control, compare cotton lint harvest yields among treatments throughout the years, determine weed species composition within the plots and monitor herbicide resistance. We monitored herbicide resistance of weeds due to the length of the experiment and the continuous monoculture cotton planted using the same herbicides applied at labeled rates year after year to the same plots, and used the same mechanical forms of cultivation throughout the experiment.

MATERIALS AND METHODS

A dry-land cotton experiment was conducted in 2006 through 2011 on a Reinach silt loam (a coarse-silty, mixed, superactive, thermic Pachic Haplustoll) soil with 51% sand, 37% silt and 12% clay and a pH of 6.5 at OSU's South Central Research station near Chickasha, OK. This site was originally developed in 1990 when weeds were established in the absence of cotton.

Devil's-claw and silverleaf nightshade were transplanted into the field as seedlings at a weed density of 3/30 m of row. Johnsongrass, large crabgrass, morningglory species consisting mostly of ivyleaf and pitted, Palmer amaranth, and Texas panicum were planted at 22 seed/m of row. Other weeds that were prevalent in this continuous monoculture cotton experiment were devil's-claw, common cocklebur, and johnsongrass. All species were allowed to mature to seed production, and then were shredded and tilled into the soil to ensure a uniform weed establishment before cotton was planted. Prior to the experiment, researchers noted that the experiment area did contain Palmer amaranth and large crabgrass, but was generally free of other weeds species.

Urea N at 112 kg/ha of 46-0-0 was applied to the plots based on past soil test and yield goal recommendations of 2.5 bales of cotton per hectare in Oklahoma prior to planting. A yield goal of 2.5 bales/ha on non-irrigated ground is typical in Oklahoma. A glyphosate-tolerant variety of Monsanto's Roundup Ready Flex® cotton was planted at a depth of 2.5 to 3.8 cm on raised seed beds with a 101.6 cm row spacing (Table 2). Plots were 12.2 meters wide by 30.5 meters long. Prior to planting, if the soil was crusted, it was broken up on the raised seed beds using a harrow or rolling cultivator. This would aid the seeds in having a better chance of getting the proper soil to seed contact that is necessary for optimum germination.

The experimental design was a randomized complete-block design with four replicates. There were 16 available herbicide treatment options applied at labeled rates and all years included the same untreated check plot from the previous year as well as the same herbicide treatment option on the same plots in subsequent years except for 2010 and 2011 (Table 3).

In 2010 and 2011, we implemented what we concluded to be our best management practices (BMP) in cotton production based on successful weed control strategies and yield data that were collected from the previous 5 yr of experiments. We used our BMP to simulate the management methods a producer would adopt in their crop production program. A producer would not apply herbicides to a crop that were unnecessary. The treatment options on the plots that did not need POST applications of herbicide were at the discretion of cotton researchers and cotton producers' typical practices. All data including weed species composition, weed counts and harvest data were collected from rows 5, 6, 7 and 8 of each plot.

Economic assessment of herbicide applications was accomplished by taking lint yield in kg/ha and multiplying by the annual price per kilogram of cotton lint. The total direct costs of herbicide and herbicide application was then subtracted from the price received for the lint. The producer could then make the decision as to which herbicide treatment option best fit their management plan and their budget.

Application timings of herbicides included preplant incorporated (PPI), preemergence (PRE), first postemergence (POST 1), second postemergence (POST 2), third postemergence (POST 3), and fourth postemergence (POST 4). Non-glyphosate applications of prometryn, metolachlor, pyrithiobac, trifluralin and quizalofop were included in some of the treatment options from 2006 through 2009. Non-glyphosate herbicide treatments will be referred to as conventional herbicide treatment options from here on.

Herbicides were applied with Tee-Jet® flat-fan, Ultra Low Drift tips using a tractor-mounted, compressed air sprayer that was calibrated to apply a carrier volume of 140.3 L/ha at a boom height of 46 cm. All herbicides were applied at labeled rates. Each year the PPI applications of herbicide ranged from 2 to 6 wk before planting. Environmental conditions accounted for the variation in PPI applications.

PRE applications of herbicides were applied immediately after planting. POST 1 applications of herbicide were applied to 2- to 8-leaf cotton throughout the entire study. This was a Roundup Ready Flex® cotton experiment, so glyphosate could be applied on an as-needed basis as long as the experiment didn't receive more than 12.6 l/ha or an application made 7 d prior to harvest. POST 2 applications of herbicides that were applied ranged from 4- to 11-wk after planting (WAP) on crop stages ranging from 4-to 10-leaf stage. POST 3 applications of herbicides that were necessary to meet weed control needs were applied at 66 d after planting (DAP) in 2006 and 80 DAP in 2010. Crop heights ranged from 66 to 112 cm for POST 3 applications of herbicide. POST 4 applications were only necessary for the 2006 growing season. This application of glyphosate was applied 92 DAP at the 66- to 76-cm cotton height. All herbicide treatments throughout this experiment were applied on clear to partly cloudy days to dry leaf surface areas. Wind speeds during application ranged from 0 to 28 km/h.

Weed counts were taken each year after all herbicide applications were made. Weeds counts within each plot were collected from rows 5, 6, 7, and 8. Average height measurement were collected and converted to mean weed numbers to total weed cm by multiplying weed numbers by the weed height. Data could be then converted into total weed cms for the entire plot. When data for weed numbers was taken, each weed was counted. If the weed within the plot was 2 cm in height or 25 cm in height, it was counted as a single weed.

Harvest dates ranged from November 9 to December 14 in the 6 yr the experiment was conducted. Rows 5, 6, 7 and 8 of each plot were harvested with a brush-roll stripper harvester. The plot yields were weighed and a “grab” sample was taken to OSU’s weed science laboratory, burr extracted and ginned to determine lint yield in kilograms/hectare. Statistical analysis of the data was done using a protected Duncan’s Multiple Range Test with PROC GLM in Statistical Analysis Systems (SAS Version 9.3). Alpha was set at 0.05. 2006 and 2010 were the only years’ that had equal replications. The other years’ experiments contained a treatment that was identical to another treatment within the treatment schedule, so unequal replications resulted.

RESULTS AND DISCUSSION

2006. Data from 2006, was the only year that the entire treatment option schedule was necessary (Table 4). All 16 treatments were applied as the management program required. There were no more than four replications of any single treatment.

POST 1, POST 2, POST 3 and POST 4 applications of glyphosate resulted in similar yields with the addition of a PPI application of trifluralin. POST 1, POST 2, POST 3, and POST 4 applications that were tank mixed with an application of pyrithiobac were equivalent to a PPI application of trifluralin followed by a PRE application of pyrithiobac, a POST 1 application of glyphosate and a POST 2 application of quizalofop. POST 1, POST 2, POST 3 and POST 4 applications of glyphosate were equivalent with a tank mixture of either pyrithiobac or metolachlor. Herbicide treatment costs that contained up to four applications of glyphosate ranged from 75.84 to 155.50 $/ha.

The most expensive treatments that yielded the least cotton lint was four applications of glyphosate with a tank mixture of POST 2 metolachlor and four applications of glyphosate with a tank mixture of POST 2 pyrithiobac. The least expensive treatment that yielded the most cotton with four applications of glyphosate was; POST 1, POST 2, POST 3, and POST 4 applications of glyphosate alone. The direct cost of this application was 75.84 $/ha. The plots that followed this treatment option yielded 363 kg/ha of lint.

Equivalent lint yields of cotton lint were obtained with the addition of a PPI application of trifluralin followed by (fb) POST 1 and POST 2 applications of glyphosate. Plots treated with trifluralin PPI fb glyphosate applied four times (POST 1, POST 2, POST 3, and POST 4) and glyphosate applied with a tank mixture of pyrithiobac were equivalent. The plots that contained a PPI application of trifluralin and more than two applications of glyphosate were equivalent, with the exception of the treatment option that contained a PRE application of pyrithiobac fb a POST 1 application of glyphosate, and a POST 2 application of quizalofop. The PRE application of pyrithiobac was effective in controlling and maintaining smaller weed heights prior to the application of the glyphosate. The glyphosate was then more effective in controlling the stunted weeds. The direct costs of herbicide and herbicide application that were associated with two applications of glyphosate ranged from 37.92 to 117.58 $/ha. The most expensive treatment option was a PPI application of trifluralin followed by glyphosate POST 1, and glyphosate POST 2 tank mixed with an application of pyrithiobac. The least expensive treatment option that contained two applications of glyphosate was POST 1 and POST applications of glyphosate. When comparing a treatment that had an PPI application of trifluralin and POST 1 application of glyphosate with the addition of a tank mixture of pyrithiobac to a treatment that contained a POST 2 application of glyphosate, and a PPI application of trifluralin followed by POST 1 and POST 2 application of glyphosate, yield was increased by 50 kg/ha. That treatment was 45% less expensive.

When an application of glyphosate was applied POST 1, the weeds had recovered well enough by harvest time to prohibit harvesting. All harvested plots had at least a PPI application of trifluralin and a single application of glyphosate somewhere in their treatment schedule. Poor or no lint yields were obtained from a single application of glyphosate applied at POST 1, and plots that were not treated at all (check), plots treated with conventional herbicides, and treatments not containing more than one application of glyphosate. When a treatment schedule that did not contain harvest data, the treatments within those plots would cost a producer 18.96 $/ha for a glyphosate alone treatment, and 224.68 $/ha for an PPI application of trifluralin fb a PRE tank mixture of prometryn and pyrithiobac fb a POST 1 application of pyrithiobac and a POST 2 application of quizalofop.   The quantity of weeds within the plots that contained these treatments, were not harvested due to high weed numbers. Although cotton was present in all plots, the labor and excessive wear on machinery prevented us from collecting harvest data from these plots.

The conventional herbicide treatment plans that did not have an application of glyphosate, were unharvestable. Weed densities for those plots ranged from 880 and 38,548 weed cm. The majority of weeds that were present within a conventional herbicide treatment plan consisted of common cocklebur and Palmer amaranth.

Plots that contained all treatments except a single application of glyphosate and the untreated check were equivalent when comparing the amount of Palmer amaranth weeds present. All treatments within the study that required a herbicide treatment controlled johnsongrass to manageable levels. The untreated check had high johnsongrass counts, which suggests that the johnsongrass was present within the study, but various herbicide applications controlled them to manageable levels. Herbicide treatment options that didn’t have an application of glyphosate within the treatment schedule did not control common cocklebur to manageable levels. All herbicide treatments that had at least one application of glyphosate within the treatment schedule, were equivalent.

2007. The treatment option schedule did not follow the initial treatment list that was necessary the previous year (Table 5). Some plots within the experiment needed the exact treatment applications that were scheduled to go on as another treatment option within the treatment scheme; therefore, there were more than four replications of the same herbicide treatment.

Two applications of glyphosate applied at POST 1 and POST 2, yielded 1720 kg/ha with virtually no weeds within the plot. This treatment option was equivalent to POST 1 and POST 2 applications of glyphosate with a tank mixture of metalochlor. The addition of trifluralin to POST 1 and POST 2 applications of glyphosate increased harvest yield by 13%. The treatments within those 16 replications remained weed free when weed counts were taken. When a PPI application of trifluralin was applied to POST 1 and POST 2 applications of glyphosate with a tank mixture of pyrithiobac, yields were equivalent. Weed counts within the plots that did not contain a PPI application of trifluralin were much higher than plots that did contain the application of trifluralin. The application of trifluralin retarded the weed emergence, and the subsequent applications of glyphosate were more effective in controlling the weeds. The application of trifluralin costs 26.26 $/ha and increased yield by 6%. A POST 1 application of glyphosate and a POST 2 application of glyphosate tank mixed with pyrithiobac yielded 1568 kg/ha.

High numbers of common cocklebur were present in conventional herbicide treatment options. With a single application of glyphosate being applied at POST 1 to treatments that contained PRE applications of pyrithiobac, weed counts and weed cm were high enough to discourage harvesting. The application of glyphosate was ineffective in controlling those weeds. It is essential that herbicide applications be made in a timely manner and at labeled rates to get desired weed control. Timely applications at labeled rates, reduces the likelihood of a weed becoming herbicide resistant. The untreated check was equivalent to applications that contained: a PPI application of trifluralin followed by a PRE application of pyrithiobac and POST 1 application of glyphosate, a single POST 1 application of glyphosate with and without a PPI application of trifluralin, and treatments that did not contain a single application of glyphosate. The most expensive treatment within the above listed parameters was a PPI application of trifluralin fb a PRE application of prometryn tank mixed with pyrithiobac and a POST 1 application of pyrithiobac.

Plots that contained all treatments except a single application of glyphosate and the untreated check were equivalent when comparing the amount of Palmer amaranth weeds present. All treatments within the study that required at least one herbicide treatment controlled johnsongrass to manageable levels. The untreated check had high johnsongrass counts, which suggests that the johnsongrass was present within the study, but various herbicide applications controlled them to manageable levels. Common cocklebur numbers were equivalent with at least one POST 1 application of glyphosate and a tank mixture application of herbicide with glyphosate. A single application of glyphosate with and without a PPI application of trifluralin controlled common cocklebur numbers the same.

2008. All plots that had yield data were equivalent in 2008 (Table 6). Plots that were not harvested were equivalent as well. To reduce weed populations to manageable levels at least two applications of glyphosate were necessary. Plots that only contained one application of glyphosate were not harvestable due to high weed numbers. Applications of glyphosate applied POST 1 and POST 2 with a POST 2 tank mixture of pyrithiobac yielded the highest amount, and only two herbicide applications were necessary. With two glyphosate only applications yield was reduced by 5%, but would save producers 57.77 $/ha at average lint yield prices. The cost of the treatments was between 37.92 $/ha and 117.58 $/ha to get plots to harvestable levels using 2008 lint prices.

The most expensive herbicide treatment option that did not control weeds to harvestable levels was an application of trifluralin PPI followed by PRE applications of prometryn and pyrithiobac tank mixed followed by a POST 1 application of pyrithiobac. That herbicide treatment cost 171.55 $/ha and did not control weeds to harvestable levels. There was a total weed cm amount of 126,308 on the most expensive herbicide treatment option. A treatment option that included four applications of herbicide would cost 163.28 $/ha with a herbicide schedule that included trifluralin applied PPI fb a PRE application of pyrithiobac fb a POST 1 application of glyphosate fb a POST 2 application of pyrithiobac. The most expensive herbicide in the treatment program was pyrithiobac applied at a rate of 0.09 kg ai/ha. The least expensive herbicide in the treatment program was glyphosate applied at a rate of 0.84 kg ai/ha.

Conventional applications of herbicide were equivalent with one and two applications of pyrithiobac were equivalent when comparing weed counts of common cocklebur. When adding a second application of pyrithiobac to a conventional herbicide treatment, common cocklebur numbers decreased by 11%. The extra application of pyrithiobac would cost the producer 35 $/ha.

2009. Treatment options that contained POST 1 and POST 2 applications with and without a PPI application of trifluralin were equivalent (Table 7). The treatment option that contained two glyphosate alone applications yielded the most cotton. With the addition of a PPI application of trifluralin, yield was 5% less when compared to two applications of glyphosate. The application of trifluralin would cost an extra 26.26 $/ha without increasing yield.

POST 1 and Post 2 applications of glyphosate with a tank mixture of metalochlor at POST 2 timing was equivalent to an application of trifluralin applied PPI followed by a PRE application of pyrithiobac followed by a POST 1 application of glyphosate. Even with 4823 weed cm in the treatment schedule that contained an application of trifluralin PPI, an application of pyrithiobac applied PRE and a POST 1 application of glyphosate, the application of glyphosate was able to increase yield by 3% and would cost 19.43 $/ha.

With the addition of a POST 2 application of pyrithiobac to a treatment schedule that contained a PPI application of trifluralin followed by PRE application of pyrithiobac followed by POST 1 application of glyphosate, yield decreased 36%.

When using an application of prometryn applied PRE tank mixed with pyrithiobac followed by a POST 1 application of pyrithiobac and a PPI application of trifluralin, those plots had a yield of 305 kg/ha, but would have a net return above treatment cost of $298.15/ha for a producer when cotton was $1.54/kg.

A POST 1 application of glyphosate, with and without a PPI application of trifluralin were ineffective in controlling weeds to harvestable levels, and had negative net returns above treatment values of 18.96 $/ha and 45.22 $/ha respectively. A single application of glyphosate alone had 77% higher counts of Palmer amaranth than the untreated check. The untreated check did not contain as many Palmer amaranth weeds within the plot, but there were more weed species present. The absence of Palmer amaranth was taken over with high counts of johnsongrass. This goes to show the species shifts that were present throughout the experiment.

2010. Researchers decided to go with the BMP based on past research data collection and producer preferences (Table 8). Research concluded that BMP was PPI applications of trifluralin followed by POST 1 and POST 2 applications of glyphosate or a PPI application of trifluralin followed by POST 1, POST 2, and POST 3 applications of glyphosate. All 64 plots within the experiment were harvested for the first time in the experiments history.

A herbicide treatment schedule that contained a PPI application of trifluralin followed by POST 1, POST 2, and POST 3 applications of glyphosate had net returns above treatment value of 181 $/ha. The POST 3 application of glyphosate increased yield by almost 10%. The POST 3 application of glyphosate would cost more than POST 1 and POST 2 applications with a PPI application of trifluralin, but had a net value of 181 $/ha. This was an increase of 4%.

Plots that only required POST 1 and POST 2 applications of glyphosate with a PPI application of trifluralin yielded 566 kg/ha. The plots within the entire experiment were virtually weed free.

2011. In 2011, Oklahoma experienced a severe drought. Although no yield data was collected, we were still able to collect weed counts within the plots. The cotton did not canopy over the rows between cotton rows, and a stand of silverleaf nightshade appeared. Silverleaf night shade cannot tolerate the shade that is present in a normal cotton producing year, so silverleaf nightshade was not as prevalent in previous years (Table 9).

Conclusion. The weeds that were most common in the study were Palmer amaranth, johnsongrass, and common cocklebur. Under adverse conditions for good cotton growth an infestation of silverleaf nightshade appeared. This was largely due to the cotton's inability to canopy over and cover the soil within the cotton row. The weeds were able to directly compete for water, nutrients and sunlight with the cotton crop without the canopy cover. Herbicide treatments containing pyrithiobac, prometryn, and quizalofop were not able to control weeds to harvestable levels in any of the years within the study, until we implemented the BMP's. The BMP option took into account past data collection, and cotton extension specialist advice. The BMP treatment program consisted of a PPI application of trifluralin, followed by POST 1 applications of glyphosate, POST 2 applications glyphosate, and if necessary a POST 3 application of glyphosate. The plots that received conventional herbicide treatments in the past needed the POST 3 application of glyphosate to get the plot to harvestable levels.

The experiment was a long term monoculture cotton study, so we were able to monitor the experiment to see if any glyphosate resistant weeds emerged. No glyphosate resistant weeds were observed. This was due to our herbicide regimen consisting of applications of herbicide that followed labeled rates, and were applied at timings that were the most effective in controlling the targeted weeds. We used typical farmer practices with this experiment as well, so any likely glyphosate resistant weeds were tilled into the soil, and could be controlled the following year with proper application of herbicide.

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Table 1. Estimated reduction in percentage of cotton yields caused by the ten most frequently reported weeds by state.

Region & state	Total % cotton loss	Morning-glories	Common cocklebur	Pig weeds	Nutsedges	Johnson grass	Prickly Sida	Silverleaf nightshade	Crab grass	Bermuda grass	Spurges
SOUTHEAST	(percentages of total %)										
Alabama	6	10	11	10	10	15	14	---	---	10	1
Florida	10	20	20	5	9	---	---	---	---	---	---
Georgia	8	6	22	1	10	4	4	---	2	---	1
North Carolina	8	30	15	6	3	2	8	---	2	3	1
South Carolina	8.5	15	19	1	15	3	8	---	1	6	4
Tennesee	10.1	10	25	6	3	12	10	---	5	5	5
MID-SOUTH											
Arkansas	9.8	20	10	5	5	10	10	---	6	5	14
Louisiana	8.4	15	15	5	8	4	11	---	4	---	4
Mississippi	1.7	17	27	5	2	8	8	1	3	3	8
Missouri	10.0	20	20	---	4	4	17	---	5	5	8
SOUTHWEST											
Oklahoma	**6.2**	**9**	**---**	**36**	**4**	**15**	**2**	**22**	**1**	**---**	**---**
Texas	**6.0**	**5**	**7**	**23**	**6**	**7**	**---**	**18**	**---**	**2**	**---**
WEST											
Arizona	10.0	10	1	10	10	7	---	9	---	6	1
California	1.0	10	---	15	16	8	---	25	---	4	---
New Mexico	6.9	25	3	2	12	10	---	9	---	3	---

Table 2. Continuous long term cotton management details from 2006-2011 at Chickasha, OK

Year	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
Cultivar Brand	NexGen 010001G3273B2RF	Stoneville ST4554B2RF	Delta and Pineland DP143B2RF	Delta and Pineland DP0935B2RF	Delta and Pineland DP1032B2RF	Fibermax 1740B2FB2RF
Planting date	June 5	May 18	May 21	June 9	May 28	May 31
Seeding rate seeds/ha	103800	128500	98800	103800	128500	128500
Application Timing	**Application dates**					
PPI	May 17	April 23	April 22	April 23	April 28	May 6
PRE	June 5	May 18	May 21	June 9	May 21	May 31
POST 1	June 29	June 13	June 12	June 24	June 8	July 1
POST 2	July 19	July 9	July 2	July 22	July 1	August 17
POST 3	August 11	---	---	---	July 20	---
POST 4	September 7	---	---	---	---	---
Defoliation date	---	October 25	October 21	October 28	October 15	---
Harvest date	December 14	November 9	November 19	November 18	November 10	---

Table 3. Proposed treatment list containing all 16 treatments[a]

Trt. No.	PPI	PRE	POST 1	POST 2	POST 3	POST 4
1	None	None	glyphosate	None	None	None
2	trifluralin	None	glyphosate	None	None	None
3	None	None	glyphosate	glyphosate	None	None
4	trifluralin	None	glyphosate	glyphosate	None	None
5	None	None	glyphosate	glyphosate + pyrithiobac	glyphosate	glyphosate
6	trifluralin	None	glyphosate	glyphosate + pyrithiobac	glyphosate	glyphosate
7	None	None	glyphosate	glyphosate + pyrithiobac	None	None
8	trifluralin	None	glyphosate	glyphosate + pyrithiobac	None	None
9	None	None	glyphosate	glyphosate + metalochlor	glyphosate	glyphosate
10	trifluralin	prometryn	pyrithiobac	quizalofop	None	None
11	trifluralin	prometryn + pyrithiobac	pyrithiobac	quizalofop	None	None
12	None	None	glyphosate	glyphosate	glyphosate	glyphosate
13	trifluralin	None	pyrithiobac	glyphosate	glyphosate	glyphosate
14	trifluralin	pyrithiobac	glyphosate	quizalofop	None	None
15	trifluralin	pyrithiobac	glyphosate	pyrithiobac	quizalofop	None
16	None	None	None	None	None	None

[a] Treatments could change at the discretion of researchers and cotton extension specialists to maintain proper weed control at present times and environmental conditions.

Table 4. Treatment options for long term Roundup Ready Flex® cotton in 2006

				Direct cost $/ha					Mean weed counts (#/plot)			Weed height (cm) Total weed (cm)		Lint yield kg/ha
No.	**Herbicide treatment[a]**	**Rate kg ai/ha**	**Method of timing[b]**	**Chemical**	**Cost of application**	**Total treatment cost**	**Gross value[c]**	**Net returns above treatment value[d]**	**AMAPA**	**SORHA**	**XANST**	**AMAPA**	**XANST**	**GOSHI**
1	GLY	0.84	POST 1	6.60	12.36	18.96	0	-18.96	3,405 a	0 b	0 c	133 a 452,865 a	0 f	Nh[e] c[f]
2	TRI GLY	1.12 0.84	PPI POST 1	13.90 6.60	12.36 12.36	45.22	95.48	50.26	619 c	0 b	110 c	122 ab 75,518 ab	53 ab 5,830 ba	62 bc
3	GLY GLY	0.84 0.84	POST 1 POST 2	6.60 6.60	12.36 12.36	37.92	308	270.08	237 c	0 b	14 c	126 a 29,862 a	19 d-f 266 d-f	200 a-c
4	TRI GLY GLY	1.12 0.84 0.84	PPI POST 1 POST 2	13.90 6.60 6.60	12.36 12.36 12.36	64.18	554.40	490.22	1 c	0 b	16 c	15 d 15 d	32 b-e 512 b-e	360 a
5	GLY GLY+ PYR GLY GLY	0.84 0.84 + 0.09 0.84 0.84	POST 1 POST 2 POST 2 POST 3 POST 4	6.60 6.60 53.40 6.60 6.60	12.36 12.36 12.36 12.36	129.24	369.60	240.36	0 c	0 b	0 c	0 d 0 d	0 f 0 f	240 a-c
6	TRI GLY GLY+ PYR GLY GLY	1.12 0.84 0.84+ 0.09 0.84 0.84	PPI POST 1 POST 2 POST 2 POST 3 POST 4	13.90 6.60 6.60 53.40 6.60 6.60	12.36 12.36 12.36 12.36 12.36	155.50	554.40	398.90	0 c	0 b	0 c	0 d 0 d	4 f 1 f	360 a
7	GLY GLY+ PYR	0.84 0.84+ 0.09	POST 1 POST 2 POST 2	6.60 6.60 53.40	12.36 12.36	91.32	562.10	470.78	35 c	0 b	16 c	88 bc 3,080 bc	34 b-e 544 b-e	365 a
8	TRI GLY GLY+ PYR	1.12 0.84 0.84 + 0.09	PPI POST 1 POST 2 POST 2	13.90 6.60 6.60 53.40	12.36 12.36 12.36	117.58	477.40	359.82	9 c	0 b	37 c	34 d 306 d	34 b-d 1,258 b-d	310 a

				Direct cost $/ha					Mean weed counts (#/plot)			Weed height (cm) Total weed (cm)		Lint yield kg/ha
No.	**Herbicide treatment[a]**	**Rate kg ai/ha**	**Method of timing[b]**	**Chemical**	**Cost of application**	**Total treatment cost**	**Gross value[c]**	**Net returns above treatment value[d]**	**AMAPA**	**SORHA**	**XANST**	**AMAPA**	**XANST**	**GOSHI**
	GLY	0.84	POST 1	6.60	12.36	113.54	415.80	302.26	0	0	5	0 d	13 ef	270
	GLY+	0.84 +	POST 2	6.60	12.36				c	b	c	0	65	ab
	MET	1.07	POST 2	37.70								d	ef	
	GLY	0.84	POST 3	6.60	12.36									
9	GLY	0.84	POST 4	6.60	12.36									
	TRI	1.12	PPI	13.90	12.36	189.68	0	-189.68	56	0	767	107 a-c	46b	Nh
	PRO	2.5	PRE	29.70	12.36				c	b	b	5,992	35,282	c
	PYR+	0.09+	POST 1	53.40	12.36							a-c	b	
	NIS[g]	0.25%		2.47										
	QUI+	0.924	POST 2	38.30										
10	NIS	0.25%		2.47	12.36									
	TRI	1.12	PPI	13.90	12.36	224.68	0	-224.68	10	0	838	88 bc	46 b	Nh
	PRO+	2.5	PRE	29.70	12.36				c	b	a	880	38,548	c
	PYR	0.06		35.00								bc	b	
	PYR+	0.09	POST 1	53.40	12.36									
	NIS	0.25%		2.47										
	QUI+	0.924	POST 2	38.30										
11	NIS	0.25%		2.47	12.36									
	GLY	0.84	POST 1	6.60	12.36	75.84	559.02	483.18	0	0	14	0 d	21 c-f	363
	GLY	0.84	POST 2	6.60	12.36				c	b	c	0	294	a
	GLY	0.84	POST 3	6.60	12.36							d	c-f	
12	GLY	0.84	POST 4	6.60	12.36									
	TRI	1.12	PPI	13.90	12.36	102.10	563.64	461.54	1	0	12	11 d	18 d-f	366
	GLY	0.84	POST 1	6.60	12.36				c	b	c	11	2,376	a
	GLY	0.84	POST 2	6.60	12.36							d	d-f	
	GLY	0.84	POST 3	6.60	12.36									
13	GLY	0.84	POST 4	6.60	12.36									
	TRI	1.12	PPI	13.90	12.36	148.18	206.36	58.18	9	0	219	72 c	72 b	134
	PYR+	0.06	PRE	35.00	12.36				c	b	c	648	15,768	a-c
	NIS	0.25%		2.47								c	a	
	GLY	0.84	POST 1	6.60	12.36									
	QUI+	0.92	POST 2	38.30	12.36									
14	NIS	0.25%		2.47										

				Direct cost $/ha					Mean weed counts (#/plot)			Weed height (cm) Total weed (cm)		Lint yield kg/ha
No.	**Herbicide treatment[a]**	**Rate kg ai/ha**	**Method of timing[b]**	**Chemical**	**Cost of application**	**Total treatment cost**	**Gross value[c]**	**Net returns above treatment value[d]**	**AMAPA**	**SORHA**	**XANST**	**AMAPA**	**XANST**	**GOSHI**
15	TRI PYR+ NIS GLY PYR+ NIS QUI+ NIS	1.12 0.06 0.25% 0.84 0.09 0.25% 0.924 0.25%	PPI PRE POST 1 POST 2 POST 3 	13.90 35.00 2.47 6.60 53.40 2.47 38.30 2.47	12.36 12.36 12.36 12.36 12.36 	216.41	489.72	273.31	2 c	0 b	100 c	99 a-c 198 a-c	44 bc 4,400 bc	318 a
16	UNTREATED CHECK	NONE	NONE	0	0	0	0	0	2,220 b	1,088 a	28 c	133 a 295,260 a	30 b-d 840 b-e	Nh c

[a]GLY= glyphosate, TRI= trifluralin, PYR= pyrithiobac, PRO= prometryn, QUI= quizalofop, and MET= metolachlor

[b]Abbreviations: PPI, preplant incorporated; PRE, preemergence; POST 1, first postemergence; POST 2, second postemergence; POST 3, third postemergence; POST 4, fourth postemergence.

[c]Gross Value was calculated using Lint Yield multiplied by Average Price ($1.54/kg) collected from Upland Cotton sales in Oklahoma

[d]Net Returns Above Treatment Value was calculated using Gross Value minus Total Treatment Cost

[e]Indicates a plot that was non harvestable (Nh) due to high weed counts

[f]Means within a column that contain the same letter are not significantly different

[g](NIS) Non-ionic surfactant applied at 0.25% volume/volume

Table 5. Treatment options for long term Roundup Ready Flex® cotton in 2007

				Direct cost $/ha					Mean weed counts (#/plot)			Weed height (cm) Total weed (cm)		Lint yield kg/ha
No.[a]	Herbicide treatment[b]	Rate kg ai/ha	Method of timing[c]	Chemical	Cost of application	Total treatment cost	Gross Value[d]	Net returns above treatment value[e]	AMAPA	SORHA	XANST	AMAPA	XANST	GOSHI
1	GLY	0.84	POST 1	6.60	12.36	18.96	0	-18.96	548 a	0 b	135 cd	137 b 75,076 a	145 b 19,575 b	Nh[f] d[g]
2	TRI GLY	1.12 0.84	PPI POST 1	13.90 6.60	12.36 12.36	45.22	0	-45.22	98 c	0 b	458 c	53 b 5,194 b	137 b 62,746 b	Nh d
3,12	GLY GLY	0.84 0.84	POST 1 POST 2	6.60 6.60	12.36 12.36	37.92	2648.80	2610.88	0 c	0 b	3 d	0 b 0 b	29 d 87 d	1720 ab
4,13	TRI GLY GLY	1.12 0.84 0.84	PPI POST 1 POST 2	13.90 6.60 6.60	12.36 12.36 12.36	64.18	3029.18	2965	0 c	0 b	8 d	0 b 0 b	13 d 104 d	1967 a
5,7	GLY GLY+ PYR	0.84 0.84 + 0.09	POST 1 POST 2 POST 2	6.60 6.60 53.40	12.36 12.36	91.32	2414.72	2323.40	87 c	0 b	5 d	27 b 2,349 b	34 d 170 d	1568 a-c
6,8	TRI GLY GLY+ PYR	1.12 0.84 0.84 + 0.09	PPI POST 1 POST 2 POST 2	13.90 6.60 6.60 53.40	12.36 12.36 12.36	117.58	2274.58	2157	8 c	0 b	9 d	15 b 120 b	34 d 306 d	1477 bc
9	GLY GLY+ MET	0.84 0.84 + 1.07	POST 1 POST 2 POST 2	6.60 6.60 37.70	12.36 12.36	75.62	2821.28	2745.66	0 c	0 b	0 d	0 b 0 b	0 d 0 d	1832 ab
10	TRI PRO PYR+ NIS[h]	1.12 2.5 0.09 0.25%	PPI PRE POST 1	13.90 29.70 53.40 2.47	12.36 12.36 12.36	136.55	0	-136.55	30 c	0 b	1,012 ab	42 b 1,260 b	130 bc 131,560 bc	Nh d
11	TRI PRO+ PYR PYR+ NIS	1.12 2.5 0.09 0.06 0.25%	PPI PRE PRE POST 1	13.90 29.70 53.40 35.00 2.47	12.36 12.36 12.36	171.55	0	-171.55	15 c	0 b	923 b	30 b 450 b	122 bc 112,606 bc	Nh d

				Direct cost $/ha					Mean weed counts (#/plot)			Weed height (cm) Total weed (cm)		Lint yield kg/ha
No.[a]	**Herbicide treatment[b]**	**Rate kg ai/ha**	**Method of timing[c]**	**Chemical**	**Cost of application**	**Total treatment cost**	**Gross Value[d]**	**Net returns above treatment value[e]**	**AMAPA**	**SORHA**	**XANST**	**AMAPA**	**XANST**	**GOSHI**
14	TRI PYR+ NIS GLY	1.12 0.06 0.25% 0.84	PPI PRE POST 1	13.90 35.00 2.47 6.60	12.36 12.36 12.36	95.05	0	-95.05	15 c	0 b	1,320 a	30 b 450 b	141 b 186,120 b	Nh d
15	TRI PYR+ NIS GLY PYR+ NIS	1.12 0.06 0.25% 0.84 0.09 0.25%	PPI PRE POST 1 POST 2	13.90 35.00 2.47 6.60 53.40 2.47	12.36 12.36 12.36 12.36	163.28	1750.98	1587.70	23 c	0 b	353 cd	27 b 621 b	95 c 33,535 c	1137 c
16	UNTREATED CHECK	NONE	NONE	0	0	0	0	0	323 b	2,198 a	473 c	38 a 12,274 b	206 a 97,438 a	Nh d

[a]Multiple numbers in the same row indicate that two or more treatments were identical and all replications were included in this row; therefore, unequal replications.

[b]GLY= glyphosate, TRI= trifluralin, PYR= pyrithiobac, PRO= prometryn, QUI= quizalofop, and MET= metolachlor

[c]Abbreviations: PPI, preplant incorporated; PRE, preemergence; POST 1, first postemergence; POST 2, second postemergence; POST 3, third postemergence; POST 4, fourth postemergence.

[d]Gross Value was calculated using Lint Yield multiplied by Average Price ($1.54/kg) collected from Upland Cotton sales in Oklahoma

[e]Net Returns Above Treatment Value was calculated using Gross Value minus Total Treatment Cost

[f]Indicates a plot that was non harvestable (Nh) due to high weed counts

[g]Means within a column that contain the same letter are not significantly different

[h](NIS) Non-ionic surfactant applied at 0.25% volume/volume

Table 6. Treatment options for long term Roundup Ready Flex® cotton in 2008

				Direct cost $/ha					Mean Weed Counts (#/plot)			Weed Height (cm) Total weed (cm)		Lint Yield kg/ha
No.[a]	**Herbicide treatment[b]**	**Rate kg ai/ha**	**Method of timing[c]**	**Chemical**	**Cost of application**	**Total treatment cost**	**Gross value[d]**	**Net returns above treatment value[e]**	**AMAPA**	**SORHA**	**XANST**	**AMAPA**	**XANST**	**GOSHI**
1	GLY	0.84	POST 1	6.60	12.36	18.96	0	-18.96	1,868 a	0 b	458 d	137 a 255,916 a	99 a 45,342 a	Nh[f] b[g]
2	TRI GLY	1.12 0.84	PPI POST 1	13.90 6.60	12.36 12.36	45.22	0	-45.22	207 b	0 b	1,673 b	80 bc 16,560 bc	84 b 140,532 b	Nh b
3,12	GLY GLY	0.84 0.84	POST 1 POST 2	6.60 6.60	12.36 12.36	37.92	1387.54	1349.62	25 b	0 b	8 d	46 c-e 1,150 c-e	15 e 120 e	901 a
4,13	TRI GLY GLY	1.12 0.84 0.84	PPI POST 1 POST 2	13.90 6.60 6.60	12.36 12.36 12.36	64.18	1362.90	1298.72	4 b	0 b	11 d	27 ef 108 ef	17 e 187 e	885 a
5,7	GLY GLY+ PYR	0.84 0.84 + 0.09	POST 1 POST 2 POST 2	6.60 6.60 53.40	12.36 12.36	91.32	1472.24	1380.92	9 b	0 b	6 d	38 d-f 342 d-f	27 e 162 e	956 a
6,8	TRI GLY GLY+ PYR	1.12 0.84 0.84 + 0.09	PPI POST 1 POST 2 POST 2	13.90 6.60 6.60 53.40	12.36 12.36 12.36	117.58	1276.66	1159.08	1 b	0 b	6 b	4 f 4 f	15 e 360 e	829 a
9	GLY GLY+ MET	0.84 0.84 + 1.07	POST 1 POST 2 POST 2	6.60 6.60 37.70	12.36 12.36	75.62	1255.10	1179.48	8 b	0 b	7 d	72 b-d 576 b-d	19 e 133 e	815 a
10	TRI PRO PYR+ NIS[h]	1.12 2.5 0.09 0.25%	PPI PRE POST 1	13.90 29.70 53.40 2.47	12.36 12.36 12.36	136.55	0	-136.55	30 b	21 b	2,170 a	99 b 2,970 b	61 d 132,370 d	Nh b

				Direct cost $/ha					Mean Weed Counts (#/plot)			Weed Height (cm) Total weed (cm)		Lint Yield kg/ha
No.[a]	**Herbicide treatment[b]**	**Rate kg ai/ha**	**Method of timing[c]**	**Chemical**	**Cost of application**	**Total treatment cost**	**Gross value[d]**	**Net returns above treatment value[e]**	**AMAPA**	**SORHA**	**XANST**	**AMAPA**	**XANST**	**GOSHI**
	TRI	1.12	PPI	13.90	12.36	171.55	0	-171.55	13	0	1,928	76 b-d	65 cd	Nh
	PRO+	2.5	PRE	29.70	12.36				b	b	ab	988	125,320	b
	PYR	0.09	PRE	53.40								b-d	cd	
	PYR+	0.06	POST 1	35.00	12.36									
11	NIS	0.25%		2.47										
	TRI	1.12	PPI	13.90	12.36	95.05	0	-95.05	6	0	2,303	88 b	76 bc	Nh
	PYR+	0.06	PRE	35.00	12.36				b	b	a	528	175,028	b
	NIS	0.25%		2.47								b	bc	
14	GLY	0.84	POST 1	6.60	12.36									
	TRI	1.12	PPI	13.90	12.36	163.28	0	-163.28	49	0	883	61 b-e	61 d	Nh
	PYR+	0.06	PRE	35.00	12.36				b	b	c	2,989	53,863	b
	NIS	0.25%		2.47								b-e	d	
	GLY	0.84	POST 1	6.60	12.36									
	PYR+	0.09	POST 2	53.40	12.36									
15	NIS	0.25%		2.47										
16	UNTREATED	NONE	NONE	0	0	0	0	0	0	2700	402	0 f	88 ab	Nh
	CHECK								b	a	d	0	35,376	b
												f	ab	

[a]Multiple numbers in the same row indicate that two or more treatments were identical and all replications were included in this row; therefore, unequal replications.

[b]GLY= glyphosate, TRI= trifluralin, PYR= pyrithiobac, PRO= prometryn, QUI= quizalofop, and MET= metolachlor

[c]Abbreviations: PPI, preplant incorporated; PRE, preemergence; POST 1, first postemergence; POST 2, second postemergence; POST 3, third postemergence; POST 4, fourth postemergence.

[d]Gross Value was calculated using Lint Yield multiplied by Average Price ($1.54/kg) collected from Upland Cotton sales in Oklahoma

[e]Net Returns Above Treatment Value was calculated using Gross Value minus Total Treatment Cost

[f]Indicates a plot that was non harvestable (Nh) due to high weed counts

[g]Means within a column that contain the same letter are not significantly different

[h](NIS) Non-ionic surfactant applied at 0.25% volume/volume

Table 7. Treatment options for long term Roundup Ready Flex® Cotton in 2009

				Direct cost $/ha					Mean Weed Counts (#/plot)			Weed Height (cm) Total weed (cm)		Lint yield kg/ha
No.[a]	Herbicide treatment[b]	Rate kg ai/ha	Method of timing[c]	Chemical	Cost of application	Total treatment cost	Gross value[d]	Net returns above treatment value[e]	AMAPA	SORHA	XANST	AMAPA	XANST	GOSHI
1	GLY	0.84	POST 1	6.60	12.36	18.96	0	-18.96	3,476 a	0 b	0 b	113 a 392,788 a	0 c 0 c	Nh[f] d[g]
2	TRI GLY	1.12 0.84	PPI POST 1	13.90 6.60	12.36 12.36	45.22	0	-45.22	705 b	0 b	134 a	84 b 59,220 b	57 a 7,638 a	Nh d
3,12	GLY GLY	0.84 0.84	POST 1 POST 2	6.60 6.60	12.36 12.36	37.92	1319.78	1281.86	61 b	0 b	3 b	46 cd 2,806 cd	2 c 6 c	857 a
4,13	TRI GLY GLY	1.12 0.84 0.84	PPI POST 1 POST 2	13.90 6.60 6.60	12.36 12.36 12.36	64.18	1244.32	1180.14	4 b	0 b	1 b	11 e 44 e	2 c 2 c	808 a
9	GLY GLY+ MET	0.84 0.84 + 1.07	POST 1 POST 2 POST 2	6.60 6.60 37.70	12.36 12.36	75.62	997.92	922.30	24 b	0 b	0 b	23 de 552 de	0 c 0 c	648 ab
11	TRI PRO+ PYR PYR+ NIS[h]	1.12 2.5 0.09 0.06 0.25%	PPI PRE PRE POST 1	13.90 29.70 53.40 35.00 2.47	12.36 12.36 12.36	171.55	469.70	298.15	116 b	0 b	21 b	72 bc 8,352 bc	40 b 840 b	305 c
14	TRI PYR+ NIS GLY	1.12 0.06 0.25% 0.84	PPI PRE POST 1	13.90 35.00 2.47 6.60	12.36 12.36 12.36	95.05	1034.88	939.83	53 b	0 b	26 b	65 bc 3,445 bc	53 ab 1,378 ab	672 ab
15	TRI PYR+ NIS GLY PYR+ NIS	1.12 0.06 0.25% 0.84 0.09 0.25%	PPI PRE POST 1 POST 2	13.90 35.00 2.47 6.60 53.40 2.47	12.36 12.36 12.36 12.36	163.28	660.66	497.38	79 b	0 b	18 b	65 bc 5,135 bc	11 c 198 c	429 bc

				Direct cost $/ha					Mean Weed Counts (#/plot)			Weed Height (cm) Total weed (cm)		Lint yield kg/ha
No.[a]	**Herbicide treatment[b]**	**Rate kg ai/ha**	**Method of timing[c]**	**Chemical**	**Cost of application**	**Total treatment cost**	**Gross value[d]**	**Net returns above treatment value[e]**	**AMAPA**	**SORHA**	**XANST**	**AMAPA**	**XANST**	**GOSHI**
16	UNTREATED CHECK	NONE	NONE	0	0	0	0	0	765 b	2768 a	0 b	46 cd 35,190 cd	0 c 0 c	Nh d

[a]Multiple numbers in the same row indicate that two or more treatments were identical and all replications were included in this row; therefore, unequal replications.

[b]GLY= glyphosate, TRI= trifluralin, PYR= pyrithiobac, PRO= prometryn, QUI= quizalofop, and MET= metolachlor

[c]Abbreviations: PPI, preplant incorporated; PRE, preemergence; POST 1, first postemergence; POST 2, second postemergence; POST 3, third postemergence; POST 4, fourth postemergence.

[d]Gross Value was calculated using Lint Yield multiplied by Average Price ($1.54/kg) collected from Upland Cotton sales in Oklahoma

[e]Net Returns Above Treatment Value was calculated using Gross Value minus Total Treatment Cost

[f]Indicates a plot that was non harvestable (Nh) due to high weed counts

[g]Means within a column that contain the same letter are not significantly different

[h](NIS) Non-ionic surfactant applied at 0.25% volume/volume

Table 8. Treatment options for long term Roundup Ready Flex® cotton in 2010

				Direct cost $/ha					Mean Weed Counts (#/plot)			Weed Height (cm) Total weed (cm)		Lint yield kg/ha
No.[a]	**Herbicide treatment[b]**	**Rate kg ai/ha**	**Method of timing[c]**	**Chemical**	**Cost of application**	**Total treatment cost**	**Gross value[d]**	**Net returns above treatment value[e]**	**AMAPA**	**SORHA**	**XANST**	**AMAPA**	**XANST**	**GOSHI**
1,2,7, 10,11, 14,15, 16	TRI GLY GLY GLY	1.12 0.84 0.84 0.84	PPI POST 1 POST 2 POST 3	13.90 6.60 6.60 6.60	12.36 12.36 12.36 12.36	83.14	967.12	883.98	0 a	0 a	0 a	0 a 0 a	0 a 0 a	628 a[f]
3,4,5, 6,8,9, 12,13	TRI GLY GLY	1.12 0.84 0.84	PPI POST 1 POST 2	13.90 6.60 6.60	12.36 12.36 12.36	64.18	871.64	807.46	0 a	0 a	0 a	0 a 0 a	0 a 0 a	566 b

[A]Indicates best management practices

[a]Multiple numbers in the same row indicate that two or more treatments were identical and all replications were included in this row; therefore, unequal replications.

[b]GLY= glyphosate, TRI= trifluralin, PYR= pyrithiobac, PRO= prometryn, QUI= quizalofop, and MET= metolachlor

[c]Abbreviations: PPI, preplant incorporated; PRE, preemergence; POST 1, first postemergence; POST 2, second postemergence; POST 3, third postemergence; POST 4, fourth postemergence.

[d]Gross Value was calculated using Lint Yield multiplied by Average Price ($1.54) collected from Upland Cotton sales in Oklahoma

[e]Net Returns Above Treatment Value was calculated using Gross Value minus Total Treatment Cost

[f]Means within a column that contain the same letter are not significantly different

Table 9. Treatment options for long term Roundup Ready Flex® cotton in 2011

				Direct cost $/ha					Mean Weed Counts (#/plot)			Weed Height (cm) Weed total (cm)		Lint yield kg/ha
No.[a]	Herbicide treatment[b]	Rate kg ai/ha	Method of timing[c]	Chemical	Cost of application	Total treatment Cost	Gross value	Net Returns Above treatment value[e]	AMAPA	SOLEI	XANST	AMAPA	XANST	GOSHI
1,2,3, 4,5,6, 7,8,9, 11,13, 14,15, 16	TRI GLY	1.12 0.84	PPI POST 1	13.90 6.60	12.36 12.36	45.22	0	-45.22	11	1	6	7 a 77	7 a 42	Nh[d]
10,12	TRI GLY GLY	1.12 0.84 0.84	PPI POST 1 POST 2	13.90 6.60 6.60	12.36 12.36 12.36	64.18	0	-64.18	8	106	13	7 a 56	16 a 208	Nh

[A]Indicates best management practices

[a]Multiple numbers in the same row indicate that two or more treatments were identical and all replications were included in this row; therefore, unequal replications.

[b]GLY= glyphosate, TRI= trifluralin, PYR= pyrithiobac, PRO= prometryn, QUI= quizalofop, and MET= metolachlor

[c]Abbreviations: PPI, preplant incorporated; PRE, preemergence; POST 1, first postemergence; POST 2, second postemergence; POST 3, third postemergence; POST 4, fourth postemergence.

[d]Indicates a plot that was non harvestable (Nh) due to high weed counts

VITA

Joshua L. Porter

Candidate for the Degree of

Master of Science

Thesis: ROUND UP READY FLEX® COTTON YIELD AND WEED COMPOSITION AFTER SIX CONTINUOUS YEARS OF THE SAME SIXTEEN HERBICIDE TREATMENTS

Major Field: Weed Science

Biographical:

Education: Graduated from DeBeque High School, DeBeque, Colorado, in 1998; received a Bachelor of Science Degree in Business Administration from University of Montana-Western, Dillon, Montana in May 2005; and completed the requirements for the Master of Science degree in Weed Science from Oklahoma State University in December 2012.

Experience: Raised on a hay and cattle ranch near New Castle, Colorado; self-employed as a hay acquisitions and forage management specialist on the western slope of Colorado after undergraduate college; worked as a Graduate Research Assistant in the Plant and Soil Science Department at Oklahoma State University, Stillwater, Oklahoma, April 2010 to June 2012.

Professional Memberships: Southern Weed Science Society, Toastmasters International Club 576-16, April 2010-June 2012.

Name: Joshua L. Porter

Date of Degree: December 2012

Institution: Oklahoma State University

Location: Stillwater, Oklahoma

Title of Study: ROUND UP READY FLEX® COTTON YIELD AND WEED COMPOSITION AFTER SIX CONTINUOUS YEARS OF THE SAME SIXTEEN HERBICIDE TREATMENTS

Pages in Study: 37

Candidate for the Degree of Master of Science

Major Field: Weed Science

Scope and Method of Study:

An experiment with Flex® cotton was started in 2006 at the South Central Research Station in Chickasha, OK. The purpose of the study was to measure weed species compositions and cotton yield in a continuous long term experiment comparing glyphosate and conventional treatments. The experimental design was a randomized complete block design with four replications and sixteen herbicide options. Plot size was 12.19 meters by 30.48 meters, with row spacing of 1 meter. All weed counts and harvest data were collected from rows 5, 6, 7, and 8 of each plot. All herbicide applications adhered to labeled rates.

Findings and Conclusions:

The weeds that were most common in the study were palmer amaranth, common cocklebur, and johnsongrass. In more droughty conditions, an infestation of silverleaf-nightshade appeared. Weed counts were taken after all treatments were applied. Cotton yield data were collected on all plots that were harvestable. Herbicides that were used in various combinations from 2006 to 2009 included trifluralin, prometryn, pyrithiobac, quizalofop, glyphosate, and metalochlor. In 2010 and 2011 when implemented our best management practices (BMP) of weed control in upland cotton. BMP included past data collection, and cotton extension specialists advice. Non glyphosate applications from 2006 thru 2009 did not control common cocklebur or Palmer amaranth, therefore, those plots were not harvested. Data collection from 2006 thru 2009 indicated that eight of the sixteen treatments were not harvested due to high populations of common cocklebur and Palmer amaranth. In 2010 the BMP were trifluralin, PPI followed by glyphosate applied POST 2 and POST 3, and trifluralin, PPI followed by glyphosate applied POST 1, POST 2, and POST 3. This herbicide program provided effective weed control over the entire experiment and we had uniform cotton lint yield. Due to an extremely dry year in 2011, cotton did not produce cotton, it also did not canopy over the row middle which allowed silverleaf-nightshade to emerge and grow. The drought conditions affect the ability of glyphosate to control the silverleaf-nightshade; therefore, there were substantial numbers of these perennial weeds.

ADVISER'S APPROVAL: Dr. Don Murray