ALTERNATIVE CONTROL PRACTICES FOR A*MARANTHUS PALMERI* RESISTANT TO ACETOLACTATE SYNTHASE INHIBITING HERBICIDES IN OKLAHOMA PEANUT FIELDS

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THESIS FORMAT

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CHAPTER I

EFFICACY AND DURATION OF PRE HERBICIDES FOR CONTROL OF PALMER AMARANTH RESISTANT TO ACETOLACTATE SYNTHASE (ALS) INHIBITING HERBICIDES

Palmer amaranth populations across western Oklahoma are developing resistance to acetolactate synthase (ALS) inhibiting herbicides. Palmer amaranth is one of the most troublesome weeds in Oklahoma peanut production today due to its rapid growth rate, high competitiveness, long germination period, and high seed production. Prior to it developing resistance to the ALS inhibiting herbicides and the adoption of no-till production systems, pendimethalin EC (the emulsifiable concentrate formulation) applied PPI and/or imazapic applied POST were commonly used for its control. With these issues in mind, on-farm and research station based experiments in southwest Oklahoma were established to evaluate ALS resistant pigweed control, in no-till and strip-till systems with various levels of herbicides imposed. Herbicide treatments included pendimethalin EC (1.1 kg ai/ha) or pendimethalin PE (the polymer encapsulated formulation) (1.1 kg ai/ha) applied PRE in the no-till plots or, PPI within the tilled zone of the strip-till unit which were applied alone or with pendimethalin PE (1.1 kg ai/ha), S-metolachlor (1.4 kg ai/ha), flumioxazin (0.045 kg ai/ha), diclosulam (0.012 kg ai/ha), dimethenamid-P (2.1 kg ai/ha), or split applications of S-metolachlor (1.4 kg/ha). Pendimethalin EC and PE incorporation was accomplished with Lilliston rolling baskets in the strip-till plots and irrigation in the no-till plots. Only the herbicide treatment effect

was significant for Palmer amaranth control and peanut yield. Pendimethalin EC (1.1 kg/ha) controlled Palmer amaranth 52% compared to 28% with pendimethalin PE (1.1 kg/ha), 53 d after treatment (DAT) at Beckham and Caddo counties respectively. PRE applications of diclosulam (0.012 kg/ha), S-metolachlor (1.4 kg/ha), dimethenamid-P (2.1 kg/ha), and pendimethalin PE (1.1 kg/ha) controlled Palmer amaranth at least 81% 53 DAT. At Caddo County pendimethalin EC (1.1 kg/ha) followed by split applications of S-metolachlor (1.4 kg/ha), applied PRE and 3 wk after planting (WAP), increased yield 287 kg/ha over pendimethalin EC (1.1 kg/ha) applied alone. Pendimethalin EC (1.1 kg/ha) followed by dimethenamid-P (2.1 kg/ha) increased yield by 214 kg/ha over the untreated check at Beckham County.

Nomenclature: diclosulam; dimethenamid; flumioxazin; metolachlor; pendimethalin; Palmer amaranth, *Amaranthus palmeri* S. Wats, AMAPA; peanut, *Arachis hypogaea* L., ARHHY.

Key words: ALS inhibiting herbicides, weed control, peanut yield loss.

Amaranthus is the genus of the pigweed family. The word is derived from the Greek word, amarantus, which means “everlasting”. Palmer amaranth (*Amaranthus palmeri* S. Wats AMAPA) are erect, glabrous, branched, herbaceous summer annuals (Fernald 1950). It can produce up to 600,000 seeds per plant (Keeley et al., 1987). Horak and Loughin (2000) conducted a 2-yr field experiment to compare several growth parameters of Palmer amaranth, common waterhemp (*Amaranthus rudis* Sauer), and redroot pigweed (*Amaranthus. retroflexus* L.). Palmer amaranth had the highest values for plant volume, dry weight, and leaf area of all species, as well as the largest rate of height increase. AMAPA’s competitiveness is a result of its capacity for rapid growth (Horak, 1997; Horak and Loughin, 2000) and its ability to spread rapidly (Keeley et al., 1987). Due to AMAPA’s recently developed resistance to the acetolactate synthase (ALS) inhibiting herbicides, it has become difficult to control in peanut (Prostko, 2001).

Although ALS inhibiting herbicides were introduced in 1982 to control weeds in cereal crops, today they are widely used in most agronomic and vegetable crops. In numerous cropping systems, ALS inhibiting herbicides are widely used as the primary source of weed control. Due to this heavy reliance on ALS inhibiting herbicides, many resistant biotypes have been selected and now dominate a once primarily susceptible population. There are nearly 95 weed species that have populations resistant to ALS inhibiting herbicides, including several *Amaranthus* sp (Heap, 2006). In continuous Oklahoma peanut fields, AMAPA has become resistant to ALS inhibiting herbicides primarily because of the repeated use of imazethapyr and imazapic for weed control.

The PRE herbicides S-metolachlor and dimethenamid-P are labeled in peanut for control of AMAPA. These active ingredients effectively control AMAPA, but the efficacy of soil-applied herbicides is dependent upon several factors, including movement of the herbicide into the soil via rainfall, irrigation, or by mechanical incorporation (Ross and Lembi 1999).

Even though peanut in the U.S. have typically been grown in conventionally tilled systems (Sholar et al., 1995), conservation tillage in peanut was introduced in the early 1970s (Sturkie and Buchanan, 1973). Adoption of conservation tillage was slow at first; however, improved pesticides (Wehtje et al., 2000), new disease-resistant peanut cultivars (Holbrook et al., 2003), and better crop rotation management (Jordan et al., 2002) have reduced pest control and crop management concerns. Increased interest in conservation tillage for peanut production has developed because of the potential for multiple cropping rotations, reduced equipment inventory and maintenance, fewer trips across the field, reduced overall power demand and fuel costs, and the ability to concentrate labor on other activities (Gallaher and Hawf, 1997).

Producers will usually adopt a production practice if there are some economic or environmental benefits. Strip-till production in peanut is an alternative tillage practice from conventional or no-till systems. There are many advantages for strip-till production systems including water conservation, reduction of tillage operations, the number of trips made across the field, improvement of soil condition, water-holding capacity (Bradley 1995), reduced wind erosion and reduced peanut injury. Strip-till production systems work well where a hardpan or plow layer exists that impedes root growth or pegging (Sholar et al. 1995). In peanut, herbicide systems are usually more challenging in strip-till when compared with conventional tillage because PPI or PRE within-the-row treatments are generally less effective when compared with conventional PPI treatments (Wilcut et al. 1987). Strip-till with Lilliston[1] units may allow producers to incorporate herbicides such as pendimethalin EC or PE within the row of the strip-till unit. Incorporation of pendimethalin is vital to the efficacy and duration of the herbicide. Pendimethalin EC has low water solubility impeding its movement into the germination zone of weeds and is subject to losses caused by photodecomposition and volatilization (Weber 1990). With strip-till and conventional tillage, herbicides are incorporated in the soil to a depth of 1 to 3 cm, where AMAPA germinates, however tillage can change seedling emergence patterns by modifying seed burial depth, dormancy, and mortality (Leon and Owen, 2006). A disadvantage of conventional and strip-till systems for peanut, compared with no-till management, is that weed seeds are brought to the surface and given proper conditions to germinate within the tilled zone (Tubbs and Gallaher, 2005).

The objective of this study was to determine the length of time that a soil applied herbicide could maintain adequate control of the AMAPA in no-till and strip-till farming systems.

MATERIALS AND METHODS

Field experiments were established on the Caddo County Research station near Ft. Cobb, OK, on a producers field near Fredrick, OK in Tillman County and on a second producers field near Erick, OK in Beckham County all sites had moderate to heavy populations of AMAPA. Experiments were conducted on a Cobb fine sandy loam (fine-loamy, mixed, active, thermic Typic Haplustalfs) at Caddo County, Grandfield loamy fine sand (fine-loamy, mixed, superactive, thermic Typic Haplustalfs) at Tillman County, and a Nobscot fine sand (loamy, mixed, superactive, thermic Arenic Paleustalfs) at Beckham County. Soil samples were collected and analyzed by the Soil, Water, and Forage Analytical Laboratory at Oklahoma State University to determine if there were any nutrient needs. Each experimental location was adequately fertilized to meet the requirements. The soil pH was 7.0 at Caddo and Tillman Counties, and 7.6 at Beckham County.

The experimental design was a split plot with the main plot factor being tillage (strip- till or no-till) and the sub plot factor being the soil applied herbicide treatments. All sub-plots were 3.6 m wide by 7.6 m long with four row plots on 90 cm centers. In the strip-till plots, either pendimethalin EC (1.1 kg ai/ha) or pendimethalin PE (1.1 kg ai/ha) was applied behind the ripper shank and incorporated with the Lilliston[1] rolling baskets mounted behind the ripper shank. Incorporation with the Lilliston[1] units was 2.5 cm deep and 22 cm wide leaving 73% of the soil surface undisturbed in the strip-till plots. Herbicide treatments included pendimethalin EC or pendimethalin PE applied PPI (in strip-till plots) and followed by (fb) or applied PRE (in no-till plots) and tank mixed with

PRE treatments of flumioxazin (0.045 kg ai/ha), diclosulam (0.012 kg ai/ha), S-metolachlor (1.4 kg ai/ha), dimethenamid-P (2.1 kg ai/ha), pendimethalin PE, and split applications of S-metolachlor (1.4 kg/ha) applied PRE and fb a 3 wk after planting (WAP) application, and an untreated check. All treatments were applied in 140 L/ha water carrier at a pressure of 210 KPa. All plots were followed by 2.54 cm of irrigation to incorporate the herbicide(s).

The peanut variety Tamspan 90 was planted May 18, 2005 at Caddo County, and Tamrun OL 02 was planted May 12, 2005 and May 17, 2005 at Beckham and Tillman Counties. Seeding rates for all locations were 100 kg/ha.

Visual weed control ratings were collected approximately 15, 30, and 45 d after the last application. Control ratings were visual estimation of plant bio-mass compared to the untreated check.

Once the residual activity of the treatments failed to provide adequate weed control, the experimental area was treated to maintain adequate weed control. At Caddo County on July 21, glyphosate (1.4 kg ai/ha) was applied to all plots with a hooded sprayer and 2 wk prior to digging, a rotary mower was used to mow the AMAPA to the height of the peanut. At Tillman County on July 28, 2,4 D-B (1.4 kg ai/ha) and clethodim (0.17 kg ai/ha) was applied with a bicycle sprayer and rope wicked with glyphosate. At Beckham County on July 27, a hooded sprayer with glyphosate (0.35 kg ai/ha) was used.

Fungicide applications followed the Oklahoma leaf spot model. In 2005, chlorothalonll (0.28 kg ai/ha) was applied to meet recommendations.

Peanut were dug on October 16 at Caddo County, on October 14 at Tillman County, and on October 6 at Beckham County. The two middle peanut rows from each plot were dug and inverted. After curing in the field for 5 d the peanut were separated from the vines with a stationary plot harvester. The peanut were dried to 12% moisture, cleaned in a stationary cleaner to remove soil and stems, and then weighed.

The PROC GLIMMIX procedure was used to determine if data could pool across locations (SAS 2005). Data could not be pooled across locations; therefore, each location was analyzed separately. Data were subjected to ANOVA and means were separated using Fisher's Protected LSD at P=0.05 through ARM 7[2].

RESULTS AND DICUSSION

Only the herbicide treatment effect was significant for AMAPA control and peanut yield. AMAPA control with pendimethalin PE applied alone was less than all other treatments at Beckham and Caddo Counties (Table 1.1). Pendimethalin EC, controlled AMAPA 52 and 89% compared to pendimethalin PE which controlled AMAPA 28 and 72% 53 d after treatment (DAT) (Table 1.1) at Beckham and Caddo Counties respectively. This may have been possible because of soil residue on the soil surface binding pendimethalin EC at Tillman County and allowing pendimethalin EC to be incorporated by irrigation at Beckham and Caddo Counties. At Beckham County, when pendimethalin EC was followed with an application of another PRE herbicide, AMAPA control increased 26% to 39%. Although NS, flumioxazin and split applications of S-metolachlor consistently provided the best control of AMAPA across all three locations. Flumioxazin 53 DAT and split applications of S-metolachlor 53 and 21 DAT controlled AMAPA 93 and 98% respectively at Tillman County. Pendimethalin EC applied PRE fb diclosulam, S-metolachlor, dimethenamid-P, or pendimethalin PE controlled AMAPA from 81 to 96% across all three experiment locations (Table 1.1). Irrigation at Caddo and Beckham Counties occurred 3 DAT, and at Tillman County, irrigation occurred 6 DAT, resulting in more AMAPA germinating and emerging before the herbicide could be incorporated by irrigation at Tillman County.

Peanut yields were low at all three locations due to significant weed competition that resulted after the residual activity of the soil applied herbicides dissipated and potential crop injury resulted from glyphosate treatments applied for their control. At Beckham County, pendimethalin EC applied with flumioxazin, diclosulam, dimethenamid-P, or pendimethalin PE out yielded more than the untreated check (Table 1.2). Pendimethalin EC applied with dimethenamid-P significantly increased yield by 214 kg/ha over the untreated check at Beckham County (Table 1.2). At Caddo County, following pendimethalin EC with split applications of S-metolachlor yield increased by 287 kg/ha over pendimethalin EC applied alone (Table 1.2). At Tillman County, pendimethalin EC applied alone yielded 700 kg/ha and was numerically lower than any other chemical treatment (Table 1.2). However, following pendimethalin EC with flumioxazin, S-metolachlor or pendimethalin PE increased yield from 140 to 280 kg/ha. These data indicate the need for POST applications to achieve adequate control of AMAPA. PRE herbicides alone do not provide adequate control of AMAPA to produce peanut successfully.

Producers relied heavily on imazapic to control a broad spectrum of weeds. However, not all populations of AMAPA in Oklahoma peanut fields are resistant to the ALS inhibiting herbicides, which can still provide adequate control of many weed species. Other studies show that diclosulam or flumioxazin applied PRE offer a more effective broad-spectrum control of a multitude of weed species (Clewis et al., 2002). Flumioxazin offers excellent control of AMAPA, but has caused peanut injury in the past, thus producers are reluctant to use this herbicide. While flumioxazin injured peanut during its first marketed year, yield was not likely influenced. Future research may show that applying dimethenamid-P PRE and following it with a lay by application of S-metolachlor will greatly extend AMAPA control later in to the season.

Source of Materials

[1] Bingham Brothers Inc., P.O. Box 3338, Lubbock, TX, 79452-3338.

[2] Agriculture Research Manager, Gylling Data Management, Inc., 405 Martin Boulevard, Brookings, SD 57006.

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Table 1.1. Effects of soil applied treatments on Palmer amaranth control at Beckham, Caddo, and Tillman Counties 53 d after planting.

		Palmer amaranth Control[1]		
Herbicides[2,3]	Rate	Beckham County	Caddo County	Tillman County
	kg ai/ha		%	
Pendimethalin EC	1.1	52d	89a	75c
Pendimethalin PE	1.1	28e	72b	82b
Pendimethalin EC + flumioxazin	1.1+0.045	78abc	97a	93a
Pendimethalin EC + diclosulam	1.1+0.012	81abc	93a	82b
Pendimethalin EC + S-metolachlor	1.1+1.4	84abc	96a	85b
Pendimethalin EC + dimethenamid-P	1.1+2.1	91a	92a	81bc
Pendimethalin EC + pendimethalin PE	1.1+1.1	82abc	93a	84b
Pendimethalin EC + S-metolachlor fb S-metolachlor[4]	1.1+1.4 fb 1.4	86ab	93a	98a

[1] Means within a column at each location followed by the same letter are not significantly different at the 0.05 level
[2]Herbicide applications were pooled over application method (PPI and PRE)
[3] Pendimethalin formulations, EC = emulsifiable concentrate formulation, or PE = polymer encapsulated formulation applied PRE
[4] Lay by applications of S-metolachlor (1.4 kg ai/ha) applied 21 d after planting

Table 1.2. Effects of soil applied treatments on peanut yield, at Beckham, Caddo, and Tillman Counties.

		Yield[1]		
Herbicides[2,3]	Rate	Beckham County	Caddo County	Tillman County
	kg ai/ha		kg/ha	
Untreated Check	----------	160c	300ab	660c
Pendimethalin EC	1.1	190bc	210b	700bc
Pendimethalin PE	1.1	140c	300ab	840abc
Pendimethalin EC + flumioxazin	1.1+0.045	290ab	250b	910ab
Pendimethalin EC + diclosulam	1.1+0.012	280ab	260b	770abc
Pendimethalin EC + S-metolachlor	1.1+1.4	230bc	380ab	980a
Pendimethalin EC + dimethenamid-P	1.1+2.1	370a	320ab	750abc
Pendimethalin EC + pendimethalinPE	1.1+1.1	300ab	360ab	980a
Pendimethalin EC + S-metolachlor fb S-metolachlor[4]	1.1+1.4 fb1.4	250bc	500a	890abc

[1] Means within a column at each location followed by the same letter are not significantly different at the 0.05 level
[2] Herbicide applications were pooled over application method (PPI and PRE)
[3] Pendimethalin formulations, EC = emulsifiable concentrate formulation, or PE = polymer encapsulated formulation applied PRE
[4] Lay by applications of S-metolachlor (1.4 kg ai/ha) applied 21 d after planting

Chapter II

PEANUT INJURY AND WEED CONTROL FROM POST HERBICIDE APPLICATIONS

CHAPTER II

PEANUT INJURY AND WEED CONTROL FROM POST HERBICIDE APPLICATIONS

Amaranthus is the genus of the pigweed family. The word is derived from the Greek word, amarantus, which means "everlasting". Research has shown significant yield reduction from the competition of the *Amaranthus* sp. in numerous crops. This experiment was conducted to evaluate peanut injury and efficacy of POST herbicide applications. In 2005, all plots received pendimethalin EC (the emulisifiable concentrate formulation) (1.1 kg/ha) PPI followed by (fb) paraquat (0.28, 0.42, 0.56, and 0.28 fb 0.28 kg ai/ha), lactofen (0.28, 0.56, and 0.28 fb 0.28 kg ai/ha), bentazon (0.56 kg ai/ha), or aciflourfen (0.28, 0.32 and 0.14 fb 0.14 kg ai/ha) applied POST. Lactofen (0.28 kg/ha) controlled small (less than 10-cm tall) pigweeds at least 94%, provided inadequate control of larger weeds, and caused minimal injury to the crop. Tank mixing bentazon (0.56 kg/ha) with paraquat (0.56 kg/ha) increased crop safety over paraquat (0.56 kg/ha) alone, but also reduced pigweed control from 86% to 39%. In 2006, treatments used to evaluate peanut injury consisted of paraquat (0.28, 0.56, and 0.84 kg/ha) with S-metolachlor (1.4 kg/ha) applied 7 d after cracking (DAC) and split applications of paraquat (0.56 kg/ha) with S-metolachlor (1.4 kg/ha) applied 14 d after first treatment. At 6 d after treatment (DAT), paraquat (0.28, 0.56, and 0.84 kg/ha) tank mixed with S-metolachlor injured peanut 56, 71, and 84%, respectively. By 36 DAT, all treatments injured peanut 20% or less, except for the split applications of paraquat (0.56 kg/ha) and S-metolachlor (1.4 kg/ha) applied 14 d after first application caused 38% injury to peanut. Paraquat applied at 0.84 kg/ha (a rate 50% higher than the highest labeled rate)

caused no more crop injury at 36 DAT than the maximum labeled rate of paraquat (i.e. 0.56 kg/ha). In 2005 and 2006, no significant yield differences were recorded among any of the treatments and/or the untreated check.

Nomenclature: acifluorfen; bentazon; lactofen; metolachlor; paraquat; pendimethalin; Palmer amaranth, *Amaranthus palmeri* S. Wats, AMAPA; peanut, *Arachis hypogaea* L., ARHHY.

Key words: ALS inhibiting herbicides, Peanut yield loss.

In the 1980s, POST broadleaf weed control in peanut was 2,4-DB, acifluorfen, bentazon, and paraquat. In 1991, imazethapyr (York et al., 2000) was labeled for PRE and POST applications and in 1996 imazapic was also labeled for use on peanut (Environmental Protection Agency, 2006). Peanut producers relied heavily on PRE and POST applications of imazethapyr and imazapic to control a multitude of weed species. Over reliance on the acetolactate synthase (ALS) inhibiting herbicides and lack of tank mixes with other herbicide modes of action to control Palmer amaranth (*Amaranthus palmeri* S. Wats AMAPA*)* may have caused the selection of resistant plants.

Weed populations resistant to ALS inhibiting herbicides have had a high frequency of occurrence. According to Tranel and Wright (2002), factors that are likely to speed the selection of resistant biotypes by a herbicide include repeated use of that herbicide over large areas, little or no use of alternative herbicide modes of action, high efficacy of the herbicide on sensitive (S) biotypes at the rate used, and soil residual activity of the herbicide. All of these factors may have contributed to the high number of weed populations resistant to ALS inhibitors. Horak and Peterson (1995) concluded that the transfer of a seed with the resistant trait to another site, which germinates, flowers, and then cross pollinates with the sensitive species, is likely one of the reasons for the development of resistance in tall waterhemp (*Amaranthus rudis* Sauer). Inadequate cleaning of tillage and/or harvest machinery between fields are possible ways the resistant weed seed are transported.

A common weed control practice in Oklahoma peanut production systems is to use S-metolachlor, dimethenamid-P, and/or pendimethalin as soil residual herbicides fb imazapic as a foliar treatment for control of AMAPA and other weeds. However, with

AMAPA becoming resistant to imazapic, other POST treatments are needed to control weeds emerging after the residual activity of soil applied herbicides fail to provide adequate control. Peanut fields infested with AMAPA will not have adequate weed control with PRE herbicides alone (Byrd and Baughman, 2002). With soil residual herbicides breaking down and allowing seedlings to emerge, POST herbicide applications are needed to achieve adequate AMAPA control. The first weed interference research in Oklahoma peanut fields was conducted by Hill and Santelmann (1969) who reported that a natural infestation of large crabgrass [*Digitaria sanguinalis* (L.) Scop.] and smooth pigweed (*Amaranthus hybridus* L.) significantly reduced Spanish peanut yield when not controlled for 4 wk after emergence, thus our plots were maintained weed free in 2006.

The efficacy of many POST herbicides is unknown for control of AMAPA in Oklahoma peanut fields. Paraquat has good efficacy on AMAPA and other weeds, but producers are reluctant to use this herbicide because of early-season injury to peanut (personal communication). This study was conducted to evaluate peanut injury and control of AMAPA populations resistant to the ALS inhibiting herbicides from POST herbicide applications.

MATERIALS AND METHODS

Experiments were established on a producers field near Erick, OK in Beckham County in 2005 and at the Caddo County Research Station near Ft. Cobb, OK in 2005 and 2006 in fields with moderate to heavy populations of AMAPA. Experiments were conducted on a Cobb fine sandy loam (fine-loamy, mixed, active, thermic Typic Haplustalfs) at Caddo County and a Nobscot fine sand (loamy, mixed, superactive, thermic Arenic Paleustalfs) at Beckham County. Soil samples from each location were collected and analyzed by the Soil, Water, and Forage Analytical laboratory of Oklahoma State University to determine nutrient needs. Each trial location was adequately fertilized to meet the nutrient recommendations. The soil pH was 7.0 at Caddo County and 7.6 at Beckham County.

The experimental design was a randomized complete block with four replications. All plots were 3.6 m wide by 7.6 m long with four rows per plot on 90 cm centers. All plots received pendimethalin EC (1.1 kg ai/ha) and S-metolachlor (1.4 kg ai/ha) applied PRE. POST herbicide treatments imposed in 2005 included acifluorfen (0.14, 0.28, 0.32 or 0.14 fb 0.14 kg ai/ha), lactofen (0.28, 0.56, or 0.56 fb 0.56 kg ai/ha), paraquat (0.28, 0.42, 0.56, or 0.28 fb 0.28 kg ai/ha), paraquat (0.28 kg/ha) applied with and without S-metolachlor (1.4 kg/ha), and bentazon (0.56 kg ai/ha). In 2006, labeled rates of paraquat (0.28 and 0.56 kg/ha) or an off-label rate of paraquat (0.84 kg/ha) tank mixed with S-metolachlor (1.4 kg/ha), and split applications of paraquat (0.56 kg/ha) applied 7 and 21 DAC with S-metolachlor (1.4 kg/ha) were applied. Paraquat was applied at labeled rates and at 50% higher than the labeled rate for a single application on peanut to evaluate peanut injury and yield loss from high rates of paraquat which might provide better weed control.

After PPI (i.e. strip-till) applications of pendimethalin EC (1.1 kg/ha) were complete, peanut varieties Tamspan 90 at Caddo County and Tamrun OL 02 at Beckham County were planted. Peanut seeding rate was 100 kg/ha at all locations. Planting occurred on May 18, 2005 and May 11, 2006 at Caddo County and May 12 at Beckham County in 2005. All treatments were applied in a 140 L/ha water carrier at a pressure of 210 kPa. In 2005, treatments were applied 3 wk after planting (WAP) with AMAPA in the two to four leaf stage. Herbicides in 2006 were applied 7 and 21 DAC.

Visual weed control ratings were collected approximately 14, 30, and 45 d after the last application in each trial. A visual estimation of biomass control of AMAPA compared to the untreated check was rated across all locations and treatments. Weeds evaluated at Caddo County in 2005 were AMAPA, yellow nutsedge [(*Cyperus esculentus* L.) CYPES], Texas Panicum [(*Panicum texanum* Buckl.) PANTE], golden crownbeard [(*Verbesina encelioides* (Cav.) Benth. & Hook. f. ex Gray) VEEEN], and entire leaf morning glory [(*Ipomoea hederacea* var. *integriuscula* Gray) IPOHG].

Once the residual activity of the treatments failed to provide adequate weed control, the entire experimental area was treated to maintain adequate weed control. At Caddo County on July 21, glyphosate (1.4 kg ai/ha) was applied to all plots with a hooded sprayer, and then 2 wk prior to digging a rotary mower was used to mow the AMAPA to the height of the peanut to assist harvesting of the crop. At Beckham County on July 27, a hooded sprayer with glyphosate (1.4 kg ai/ha) was used. In 2006, plots were maintained weed free, mechanically by the use of hoes or hand pulling.

Fungicide applications followed the Oklahoma leaf spot model. In 2005 and 2006, chlorothalonll (0.28 kg ai/ha) was applied to meet recommendations.

Peanut were dug on October 16 at Caddo County and October 6 at Beckham County. The two middle peanut rows from each plot were dug and inverted. After curing in the field for 5 d the peanut were separated from the vines with a stationary plot harvester. The peanut were dried to 12% moisture, cleaned in a stationary cleaner to remove soil and stems, and then weighed.

The PROC GLIMMIX procedure was used to determine if data could be pooled across locations (SAS 2005). Due to the varying data points across all locations, data could not be pooled across locations; therfore each location was analyzed separately. Data were subjected to ANOVA using ARM 7[2]. Means were separated using Fisher's Protected LSD at P=0.05.

RESULTS AND DISCUSSION

In 2005, neither paraquat, lactofen, nor acifluorfen did not cause any visual injury to the peanut by 4 WAT. However, there were differences in the efficacy on the various weed species.

At Beckham County, paraquat (0.42 kg/ha) controlled AMAPA at least 78% 30 DAT (Table 2.1). Paraquat (0.28 kg/ha) tank mixed with bentazon (0.56 kg/ha) controlled AMAPA 39% 30 DAT. Tank mixing paraquat with bentazon increased crop safety over paraquat alone, but also reduced pigweed control from 91% to 39%. Including S-metolachlor with paraquat and bentazon returned weed control to levels of paraquat applied alone. AMAPA was controlled at least 98% at Caddo County in 2005 (Table 2.1). Plots received 2.54 cm of irrigation per week and resulted in multiple germinations of AMAPA at Beckham County; therefore, separation of treatments occurred by 30 DAT. However, at Caddo County, high infestations of other weed species prevented later emergence of AMAPA.

CYPES control was not different among any of the paraquat treatments. Paraquat treatments controlled CYPES at least 87% 54 DAT (Table 2.2). With lactofen and acifluorfen control of CYPES improved with increasing rates or when sequential applications were applied.

PANTE control with paraquat (0.28, 0.56, or 0.28 fb 0.28 kg/ha) was at least 81% 54 DAT (Table 2.2). Paraquat (0.28 kg/ha) tank mixed with bentazon (0.56 g/ha) controlled PANTE 69%, but including S-metolachlor (1.4 kg/ha) in this treatment it increased control to 95% 54 DAT. Tank mixing bentazon with paraquat has a safening affect on the PANTE, as well as the peanut, but when S-metolachlor (1.4 kg/ha) was added to the tank mix, efficacy was restored and PANTE control returned to greater than 90%. This will allow producers to control PANTE as well as extend the residual activity later into the season. With lactofen and acifluorfen control of PANTE numerically increased with increasing rates or sequential applications except for acifluorfen (0.32 kg/ha), which controlled PANTE 45% 54 DAT. VEEEN control numerically increased with higher rates or sequential applications except for sequential applications of acifluorfen (0.14 fb 0.14 kg/ha). Acifluorfen (0.32 kg/ha) controlled IPOHG 94%. All other treatments controlled IPOHG at least 71%.

After POST herbicide applications were made, weed species were germinating including AMAPA, CYPES, PANTE, VEEEN, and IPOHG (Table 2.2). Due to the lack of residual activity of the POST herbicides, the entire experimental area was treated with glyphosate, and injured peanut resulted in lower yields than normal. There was no significant difference in peanut yield at Caddo or Beckham Counties in 2005 (Table 2.3). POST herbicide applications only control weeds that are already emerged.

In 2006, at 6 DAT, paraquat (0.28, 0.56 and 0.84 kg/ha) tank mixed with S-metolachlor (1.4 kg/ha) injured peanut 56, 68 and 54% respectively (Table 2.4). By 36 DAT peanut injury increased with increasing rates of paraquat. Paraquat (0.28, 0.56, 0.84 and 0.56 fb 0.56 kg/ha) tank mixed with S-metolachlor (1.4 kg/ha) injured peanut 3, 13, 20 and 38 % respectively (Table 2.4). Peanut injury from paraquat (0.56 fb 0.56

kg/ha) tank mixed with S-metolachlor (1.4 fb 1.4 kg/ha) was higher than paraquat (0.28, 0.56, and 0.84 kg/ha) tank mixed with S-metolachlor (1.4 kg/ha) 36 DAT (Table 2.4). Paraquat (0.56 kg/ha) and paraquat (0.84 kg/ha) which is 50% over the labeled rate of paraquat tank mixed with S-metolachlor (1.4 kg/ha), was NS at 36 DAT (Table 2.4). Even when paraquat rates were increased 50% over the label rate, there was no significant peanut injury visible, resulting in control of AMAPA that was better than with lower rates.

Even when plots were maintained weed-free, peanut yields were low. Producers in Oklahoma have a perception that early season peanut injury from paraquat reduces yield, but this research shows that there is no significant yield difference between any of the paraquat rates when compared to the untreated check. Peanut injury from paraquat (0.28, 0.56, 0.84, and 0.56 fb 0.56 kg/ha) did not significantly reduce yield, but did delay canopy closure (data not shown), which possibly allowed weed seedlings to emerge later in the season.

These data indicate a need for PRE herbicides to be tank mixed with POST herbicides to achieve acceptable weed control. POST herbicides are not enough to control weeds all season long. Paraquat controlled AMAPA up to 54 DAT (Table 2.1) when compared to the untreated check when rated for biomass reduction, but there were many seedlings that were emerging from the cotyledon to the 5 leaf stage. With this in mind we must tank mix a PRE herbicide in the tank to facilitate an extension of the residual activity later into the season.

Source of Materials

[1] Bingham Brothers Inc., P.O. Box 3338, Lubbock, TX, 79452-3338.

[2] Agriculture Research Manager, Gylling Data Management, Inc., 405 Martin Boulevard, Brookings, SD 57006.

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Table 2.1. Palmer amaranth control with POST treatments at Caddo and Beckham Counties, 30 d after treatment in 2005.

Herbicide[2,3]	Rate	AMAPA Control 30 DAT[1] Caddo County	Beckham County
	kg ai/ha	—— % ——	
Acifluorfen	0.28	99a	98a
Acifluorfen	0.32	99a	94a
Acifluorfen fb acifluorfen	0.14 fb 0.14	99a	84a
Lactofen	0.28	99a	94a
Lactofen	0.56	99a	95a
Lactofen fb lactofen	0.28 fb 0.28	99a	97a
Paraquat	0.28	99a	91a
Paraquat	0.42	99a	78a
Paraquat	0.56	98a	86a
Paraquat fb paraquat	0.28 fb 0.28	99a	83a
Paraquat + bentazon	0.28 + 0.56	99a	39b
Paraquat + bentazon + S-metolachlor	0.28 + 0.56 + 1.4	98a	83a

[1] Means within a column at each location followed by the same letter are not significantly different at the 0.05 level.
[2] pendimethalin EC (1.1 kg ai/ha) applied PPI
[3] All POST applications were made with .25% volume/volume nonionic surfactant.

Table 2.2. Weed control with POST treatments at Caddo County in 2005.

		Caddo County 54 DAT[1]			
Herbicide[2,3]	Rate	CYPES	PANTE	VEEEN	IPOHG
	kg ai/ha	%			
Acifluorfen	0.28	3e	66abc	85ab	89ab
Acifluorfen	0.32	20de	45bcd	93ab	94a
Acifluorfen fb acifluorfen	0.14 fb 0.14	78ab	82a	79b	76ab
Lactofen	0.28	0e	30d	89ab	84ab
Lactofen	0.56	54bc	43cd	91ab	86ab
Lactofen fb lactofen	0.28 fb 0.28	43cd	87a	97a	89ab
Paraquat	0.28	97a	81a	73b	75ab
Paraquat	0.42	92a	83a	82b	71b
Paraquat	0.56	94a	86a	89ab	74ab
Paraquat fb paraquat	0.28 fb 0.28	87a	86a	86ab	81ab
Paraquat + bentazon	0.28 + 0.56	93a	69abc	89ab	75ab
Paraquat + bentazon + S-metolachlor	0.28 + 0.56 + 1.4	98a	95a	94ab	85ab

[1] Means within a column at each location followed by the same letter are not significantly different at the 0.05 level.
[2] pendimethalin EC (1.1 kg ai/ha) applied PPI
[3] All POST applications were made with .25% volume/volume nonionic surfactant.

Table 2.3. Effects of POST treatments on peanut yield at Caddo and Beckham Counties in 2005.

Herbicide[2,3]	Rate	Yield[1] Caddo County	Yield[1] Beckham County
	kg ai/ha	kg/ha	
Untreated Check	---------	435a	106a
Acifluorfen	0.28	457a	288a
Acifluorfen	0.32	470a	345a
Acifluorfen fb acifluorfen	0.14 fb 0.14	582a	327a
Lactofen	0.28	470a	181a
Lactofen	0.56	435a	357a
Lactofen fb lactofen	0.28 fb 0.28	592a	377a
Paraquat	0.28	533a	271a
Paraquat	0.42	488a	315a
Paraquat	0.56	527a	223a
Paraquat fb paraquat	0.28 fb 0.28	443a	191a
Paraquat + bentazon	0.28 + 0.56	437a	201a
Paraquat + bentazon + S-metolachlor	0.28 + 0.56 + 1.4	534a	348a

[1] Means within a column at each location followed by the same letter are not significantly different at the 0.05 level.
[2] pendimethalin EC (1.1 kg ai/ha) applied PPI
[3] All POST applications were made with .25% volume/volume nonionic surfactant.

Table 2.4. Percent peanut injury recorded 6 and 36 d after treatment at Caddo County, OK.

Herbicide[2]	Application	Rate	D after Treatment[1]	
			6	36
		kg ai/ha	Peanut Injury (%)	
Paraquat + S-metolachlor	EPOST	0.28 + 1.4	56bc	3c
Paraquat + S-metolachlor	EPOST	0.56 + 1.4	68ab	13b
Paraquat + S-metolachlor	EPOST	0.84 + 1.4	54c	20b
Paraquat + S-metolachlor fb paraquat	EPOST fb LPOST	0.56 + 1.4 fb 0.56	73a	38a

[1] Means within a column at each location followed by the same letter are not significantly different at the 0.05 level

[2] All applications were made with 0.25% volume/volume nonionic surfactant.

Table 2.5. Effects of paraquat rates on peanut yields at Caddo County, OK.

Herbicide[2]	Application	Rate	Yield[1] Caddo County
		kg ai/ha	kg/ha
Untreated Check		---------	323a
Paraquat + S-metolachlor	EPOST	0.28 + 1.4	307a
Paraquat + S-metolachlor	EPOST	0.56 + 1.4	334a
Paraquat + S-metolachlor	EPOST	0.84 + 1.4	284a
Paraquat + S-metolachlor fb paraquat	EPOST fb LPOST	0.56 + 1.4 fb 0.56	296a

[1] Means within a column at each location followed by the same letter are not significantly different at the 0.05 level

[2] All applications were made with 0.25% volume/volume nonionic surfactant.

Chapter III

HERBICIDE PROGRAM OPTIONS FOR SEASON-LONG CONTROL OF PALMER AMARANTH RESISTANT TO ACETOLACTATE SYNTHASE (ALS) INHIBITING HERBICIDES IN OKLAHOMA PEANUT FIELDS.

CHAPTER III

HERBICIDE PROGRAM OPTIONS FOR SEASON-LONG CONTROL OF PALMER AMARANTH RESISTANT TO ACETOLACTATE SYNTHASE (ALS) INHIBITING HERBICIDES IN OKLAHOMA PEANUT FIELDS.

Palmer amaranth *(Amaranthus palmer* S. Wats*)* is one of the most troublesome weeds in Oklahoma peanut production today due to its rapid growth rate, high competitiveness, long germination period, high seed production potential, and its resistance to acetolactate synthase (ALS) inhibiting herbicides. With these issues in mind, on-farm and research station-based trials were established in southwest Oklahoma to evaluate tank mixes of residual and contact-type herbicide applications on Palmer amaranth control and peanut yields. Herbicides imposed in 2005 were pendimethalin EC (the emulsifiable concentrate formulation) (1.1 kg ai/ha), which was applied behind the ripper shank and incorporated with Lilliston rolling baskets mounted behind the ripper shank followed by (fb) POST applications of paraquat (0.56 kg ai/ha) tank mixed with S-metolachlor (1.4 kg ai/ha), pendimethalin EC (1.1 kg ai/ha), pendimethalin PE (the polymer encapsulated formulation) (1.1 kg ai/ha), or dimethenamid-P (2.1 kg ai/ha). In 2006, pendimethalin PE (1.1 kg/ha) was applied PRE followed with an EPOST application of S-metolachlor (1.4 kg ai/ha) or dimethenamid-P (2.1 kg ai/ha) tank mixed with paraquat (0.56 g ai/ha), lactofen (0.22 kg ai/ha), or carfentrazone-ethyl (0.014 kg ai/ha) plus 2,4-DB (0.35 kg ai/ha). In 2005, all treatments at Caddo and Beckham Counties controlled Palmer

amaranth at least 86% 30 d after treatment (DAT) and no significant yield difference was observed. In 2006, across all locations paraquat (0.56 kg/ha) tank mixed with S-metolachlor (1.4 kg/ha) or dimethenamid-P (2.1 kg/ha) controlled Palmer amaranth at least 89% 20 DAT. Carfentrazone-ethyl (0.014 kg ai/ha) plus 2,4-DB (0.35 kg ai/ha) tank mixed with S-metolachlor (1.4 kg/ha) or dimethenamid-P (2.1 kg/ha) controlled Palmer amaranth at least 91% 20 DAT at all three locations. Across all locations, no herbicide treatment affected peanut yield.

Nomenclature: carfentrazone; dimethenamid; lactofen; metolachlor; paraquat; pendimethalin; 2,4-DB; Palmer amaranth, *Amaranthus palmeri* S. Wats, AMAPA; peanut, *Arachis hypogaea* L., ARHHY.

Key words: ALS inhibiting herbicides, peanut yield loss, weed control.

Palmer amaranth (*Amaranthus palmeri* S. Wats AMAPA) has the ability to produce 600,000 seeds per single plant; therefore, resistant AMAPA can rapidly multiply (Keeley et al. 1987). AMAPA is native to the southern Great Plains, with a distribution encompassing the southern half of the United States (Steyermark 1963). Research has shown significant yield reduction from the competition of the *Amaranthus* sp. Weed seed banks in agro-ecosystems naturally contain a large quantity of many weed species (Forcella et al. 1992). AMAPA may emerge from the soil as early as March 1 and as late as October 1 in southern California (Keeley et al. 1987). Wright et al. (1999) showed that AMAPA's germination responds negatively to low temperature, but positively to high temperature. With AMAPA emerging from the soil nearly all season long, PRE and POST herbicide applications are necessary to achieve season long weed control. In 1995, Kansas researchers found populations of both AMAPA and common waterhemp (*Amaranthus rudis* Sauer) that were resistant to ALS inhibitors (Horak and Peterson 1995). These two biotypes were described as having resistance to imazethapyr and thifensulfuron, two ALS enzyme inhibitors (Sprague et al. 1997). However, researchers are unsure if these two biotypes developed independent resistance (Franssen et al. 2001).

POST herbicide application timing is extremely important in peanut weed control (Prosko, 2002). In the 1980s POST broadleaf weed control in peanut was limited to 2,4-DB, acifluorfen, bentazon, and paraquat. In 1991 imazethapyr (York et al., 2000) was labeled for PRE and POST applications and in 1996 imazapic (Environmental Protection Agency, 2006) was also labeled for use in peanut. With soil residual herbicides breaking down and allowing seedlings to emerge, POST herbicide applications are used to achieve adequate AMAPA control.

Production agriculture has moved to the use of no-till, strip till, and environmentally safe herbicides because of the increasing fuel cost, equipment cost, labor cost, soil erosion, and environmental issues. These practices have altered weed populations that are better suited to this environment (Wax, 1995). With the increasing adoption of no-till and strip-till, incorporation of pendimethalin has been accomplished by irrigation. Incorporation of pendimethalin is vital to its efficacy and duration. With strip-till and conventional tillage, herbicides are incorporated in the soil to a depth of 1 to 3 cm where AMAPA germinates, however tillage can change seedling emergence patterns by modifying seed burial depth, dormancy, and mortality (Leon and Owen, 2006). Strip-till with Lilliston[1] units may allow producers to incorporate herbicides such as pendimethalin EC or PE within the row of the strip-till unit.

It is imperative to develop a weed control system in limited tillage systems for control of AMAPA in peanut. This research was initiated to develop a season-long weed control program for Oklahoma peanut producers.

MATERIALS AND METHODS

Two experiments were established on the Caddo County Research Station near Ft. Cobb, OK, and on a producers field near Erick, OK in Beckham County in 2005 and 2006, and on a second producers field near Weatherford, OK in Custer County in 2006 in fields infested with moderate to heavy populations of AMAPA. Experiments were conducted on a Cobb fine sandy loam (fine-loamy, mixed, active, thermic Typic Haplustalfs) at Caddo County, a Nobscot fine sand (loamy, mixed, superactive, thermic Arenic Paleustalfs) at Beckham County and a Pond Creek fine sand loam (fine-silty, mixed, superactive, thermic Pachic Argiustolls) at Custer County. Soil samples from each location were collected and analyzed by the Soil, Water, and Forage Analytical laboratory of Oklahoma State University to determine the nutrient requirements. Each trial was fertilized to meet the requirements. The soil pH was 7.0 at Caddo County, 7.6 at Beckham County, and 7.4 at Custer County.

The experimental design was a randomized complete block with four replications. All plots were 3.6 m wide by 7.6 m long with four rows plot on 90 cm centers. In 2005, pendimethalin EC (1.1 kg ai/ha) was applied behind the ripper shank and incorporated with the Lilliston[1] rolling baskets mounted behind the ripper shank. Incorporation with the Lilliston[1] units was 2.5 cm deep and 22 cm wide, leaving 73% of the soil surface undisturbed in the strip-till plots.

After pendimethalin EC applications were complete, peanut variety Tamspan 90 was planted at Caddo and Custer Counties and Tamrun OL 02 Beckham County. At all locations, peanut were planted at 100 kg/ha. Planting occurred on May 18, 2005 at Caddo County and May 12, 2005 at Beckham County. Planting occurred on May 11, 2006 at Caddo County, May 16, 2006 at Beckham county and May 22, 2006 at Custer County.

POST herbicide applications in 2005 included paraquat (0.56 kg ai/ha) tank mixed with S-metolachlor (1.4 kg ai/ha), pendimethalin EC (1.1 kg ai/ha), pendimethalin PE (1.1 kg ai/ha), or dimethenamid-P (2.1 kg ai/ha). In 2006, PRE applications included S-metolachlor (1.4 kg ai/ha) or dimethenamid-P (2.1 kg ai/ha) tank mixed with paraquat (0.56 kg ai/ha), lactofen (0.22 kg ai/ha), or carfentrazone-ethyl (0.014 kg ai/ha) plus 2,4-DB (0.35 kg ai/ha).

All treatments were applied in 140 L/ha water carrier at a pressure of 210 KPa. In 2005, applications were applied 7 d after cracking (DAC) with AMAPA at cotyledon to five leaf stage. In 2006, applications were made PRE to the peanut crop and AMAPA in the cotyledon to two leaf stage.

Visual weed control ratings were collected approximately 14, 30, and 45 d after the last application in each trial. A visual estimation of biomass control of AMAPA compared to the untreated check was rated across all locations and treatments.

Once the residual activity of the treatments failed to provide adequate weed control, the experimental area was treated to maintain adequate weed control. At Caddo County on July 21, glyphosate (1.4 kg ai/ha) was applied to all plots with a hooded sprayer and then 2 wk before digging, a rotary mower was used to mow the AMAPA to the height of the peanut to assist peanut harvest. At Beckham County on July 27, a hooded sprayer with glyphosate (1.4 kg/ha) was used. In 2006, plots were sprayed with a blanket application of S-metolachlor (1.4 kg/ha) tank mixed with paraquat (0.54 kg/ha) at all locations.

Fungicide applications followed the Oklahoma leaf spot model. In 2005 and 2006, chlorothalonll (0.2 kg ai/ha) was applied to meet recommendations.

Peanut were dug on October 16, 2005 at Caddo County and October 6, 2005 at Beckham County. Digging took place on October 20, 2006 at Caddo County, October 11, 2006 at Beckham County, and October 13, 2006 at Custer County. In 2005, the two middle peanut rows from each plot were dug and inverted. After curing in the field for 5 d the peanut were separated from the vines with a stationary plot harvester. Plots in 2006 were harvested with a Lilliston[1] 1500 two row combine at Caddo County and a stationary plot harvester was utilized at Beckham and Custer Counties. The peanut were bagged and brought back to the dryer were they spent a week to reach a moisture content of 12%. Upon completion of drying, the peanut were cleaned in a stationary cleaner to remove soil and stems and then weighed.

The PROC GLIMMIX procedure was used to determine if data could be pooled across locations (SAS 2005). Due to the varying data points across all locations, data could not be pooled across locations; therfore each location was analyzed separately. Data were subjected to ANOVA using ARM 7[2]. Means were separated using Fisher's Protected LSD at P=0.05.

RESULTS AND DICUSSION

In 2005, all treatments at Caddo and Beckham Counties controlled AMAPA at least 86% 30 DAT (Table 3.1) when compared to the untreated check. By 30 DAT, many seedlings were emerging and were in the cotyledon to five leaf stage. After these ratings the efficacy of the herbicides was no longer visible and blanket treatments were applied to maintain harvestable peanut.

S-metolachlor (1.4 kg/ha) or dimethenamid-P (2.1 kg/ha) tank mixed with paraquat (0.56 kg/ha) controlled yellow nutsedge [(*Cyperus esculentus* L.) CYPES] 97% and 96% 54 DAT respectively (Table 3.2). None of the applications resulted in complete control of CYPES. S-metolachlor (1.4 kg/ha) or pendimethalin EC (1.1 kg ai/ha) tank mixed with paraquat (0.56 kg/ha) controlled Texas Panicum [(*Panicum texanum* Buckl.) PANTE] at least 94%, which was better than dimethenamid-P (2.1 kg/ha) tank mixed with paraquat (0.56 kg/ha), which controlled it 87%. Golden Crownsbeard {[*Verbesina encelioides* (Cav.) Benth. & Hook. f. ex Gray] VEEEN} was controlled at least 92% 54 DAT (Table 3.2) by all treatments. Pendimethalin EC (1.1 kg/ha) tank mixed with paraquat (0.56 kg/ha) controlled entire leaf morning glory [(*Ipomoea hederacea* var. *integriuscula* Gray) IPOHG] better than all other treatments except for S-metolachlor (1.4 kg/ha) tank mixed with paraquat (0.56 kg/ha) (Table 3.2). In general, tank-mixing paraquat (0.56 kg/ha) with S-metolachlor (1.4 kg/ha) increased the duration of control later into the season among all weed species.

No significant yield differences existed among all treatment, at Caddo and Beckham Counties in 2005 (Table 3.3). Peanut yields were extremely low at both locations due to significant weed competition that resulted after the residual activity of the soil applied herbicides dissipated and potential crop injury resulting from blanket glyphosate treatments applied for their control.

In 2006, paraquat (0.56 kg/ha), lactofen (0.22 kg/ha), or carfentrazone-ethyl (0.014 kg ai/ha) plus 2,4-DB (0.35 kg ai/ha) did not cause any visual injury to the peanut at the time of rating. However, there were differences in the efficacy of treatments on the various weed species.

Across all locations in 2006, paraquat (0.56 kg/ha) tank mixed with S-metolachlor (1.4 kg/ha) or dimethenamid-P (2.1 kg/ha) controlled AMAPA at least 89% 20 DAT (Table 3.4). Lactofen (0.22 kg/ha) tank mixed with S-metolachlor (1.4 kg/ha) or dimethenamid-P (2.1 kg/ha) controlled AMAPA at Caddo East, Caddo West, and Beckham Counties at least 80% 20 DAT (Table 3.4). At Custer County, lactofen (0.22 kg/ha) tank mixed with dimethenamid-P (2.1 kg/ha) controlled AMAPA 58% 20 DAT (Table 3.4). Carfentrazone-ethyl (0.014 kg ai/ha) plus 2,4-DB (0.35 kg ai/ha) tank mixed with S-metolachlor (1.4 kg/ha) or dimethenamid-P (2.1 kg/ha) controlled AMAPA at least 91% 20 DAT at Caddo East, Caddo West, and Custer Counties (Table 3.4). This treatment at Beckham County controlled AMAPA 84 and 76% respectively (Table 3.4).

In 2006, all treatments controlled CYPES at least 89%. Control of PANTE with paraquat (0.56 kg/ha) tank mixed with S-metolachlor (1.4 kg/ha) or dimethenamid-P (2.1

kg/ha) was at least 58% (Table 3.5). PANTE control with all other treatments was below 30% (Table 3.5). All treatments controlled IPOHG 70% or greater except for lactofen (0.22 kg/ha) tank mixed with S-metolachlor which controlled it 60% (Table 3.5). In 2006, S-metolachlor (1.4 kg/ha) or dimethenamid-P tank mixed with paraquat (0.56 kg/ha) or carfentrazone-ethyl (0.014 kg ai/ha) plus 2,4-DB (0.35 kg ai/ha) controlled VEEEN 83% (Table 3.5). Dimethenamid-P tank mixed with paraquat (0.56 kg/ha), lactofen (0.22 kg/ha), or carfentrazone-ethyl (0.014 kg ai/ha) plus 2,4-DB (0.35 kg ai/ha) provided more consistent control of CYPES, PANTE, IPOHG, and VEEEN 18 DAT (Table 3.5). Although not evaluated, this treatment maybe used for PRE applications and followed by lay by application of S-metolachlor (1.4 kg/ha) tank mixed with paraquat (0.56 kg/ha) to extend residual activity later in the season.

Peanut yields were extremely low at all locations due to significant weed competition and blanket treatments of glyphosate applied to maintain harvestable plots. Among all treatments and all locations in 2006, there was no significant yield difference.

These data indicates that tank-mixing applications of PRE and POST herbicides are not enough to control AMAPA populations in Oklahoma peanut producing areas year after year. Applying a PRE herbicide prior to irrigation and allowing seedlings to emerge then following 5-8 d after the PRE application with a POST application, could assist in controlling AMAPA already germinated when the PRE herbicide was applied. With AMAPA germinating all season long it is essential to get PRE herbicides in place and working before applying POST herbicides. Paraquat treatments were consistently more effective for control of AMAPA than the lactofen and carfentrazone plus 2,4-DB treatments.

Source of Materials

[1] Bingham Brothers Inc., P.O. Box 3338, Lubbock, TX, 79452-3338.

[2] Agriculture Research Manager, Gylling Data Management, Inc., 405 Martin Boulevard, Brookings, SD 57006.

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Table 3.1. Palmer amaranth control with PRE and POST herbicides tank mixed, at Caddo and Beckham Counties in 2005.

		AMAPA Control 30 DAT[1]	
Herbicide[2,3]	Rate	Caddo County	Beckham County
	kg ai/ha	%	
Paraquat + S-metolachlor	0.56 + 1.4	99a	94a
Paraquat + pendimethalin PE	0.56 + 1.1	99a	88a
Paraquat + pendimethalin EC	0.56 + 1.1	99a	86a
Paraquat + dimethenamid-P	0.56 + 2.1	99a	92a

[1] Means within a column at each location followed by the same letter are not significantly different at the 0.05 level.

[2] Pendimethalin formulations, EC = emulsifiable concentrate formulation, or PE = polymer encapsulated formulation applied PRE

[3] All applications were made with 0.25% volume/volume nonionic surfactant.

Table 3.2. Weed control with PRE and POST herbicides tank mixed, at Caddo County in 2005.

		Caddo County 54 DAT [1]			
Herbicide[2,3]	Rate	CYPES	PANTE	VEEEN	IPOHG
	kg ai/ha	%			
Paraquat + S-metolachlor	0.56 + 1.4	97a	96a	97a	90ab
Paraquat + pendimethalin PE	0.56 + 1.1	93ab	89b	96a	93a
Paraquat + pendimethalin EC	0.56 + 1.1	91b	94ab	92a	80b
Paraquat + dimethenamid-P	0.56 + 2.1	96a	87b	97a	79b

[1] Means within a column at each location followed by the same letter are not significantly different at the 0.05 level.

[2] Pendimethalin formulations, EC = emulsifiable concentrate formulation, or PE = polymer encapsulated formulation applied PRE

[3] All applications were made with 0.25% volume/volume nonionic surfactant.

Table 3.3. Effects of PRE and POST herbicides tank mixed, on peanut yield, at Caddo and Beckham Counties in 2005

Herbicide[2,3]	Rate	Yield[1]	
		Caddo County	Beckham County
	kg ai/ha	kg/ha	
Untreated Check	-----------	387a	275a
Paraquat + S-metolachlor	0.56 + 1.4	482a	385a
Paraquat + pendimethalin PE	0.56 + 1.1	525a	270a
Paraquat + pendimethalin EC	0.56 + 1.1	497a	280a
Paraquat + dimethenamid-P	0.56 + 2.1	657a	402a

[1] Means within a column at each location followed by the same letter are not significantly different at the 0.05 level.

[2]Pendimethalin formulations, EC = emulsifiable concentrate formulation, or PE = polymer encapsulated formulation applied PRE

[3] All applications were made with 0.25% volume/volume nonionic surfactant.

Table 3.4. Palmer amaranth control in PRE treatments, combined with POST treatments, at Caddo East and West, Custer, and Beckham Counties in 2006.

Herbicide[2]	Rate	AMAPA Control 20 DAT[1]			
		Caddo County East	Caddo County West	Custer County	Beckham County
	kg ai/ha	%			
carfentrazone-ethyl + 2,4-DB + S-metolachlor	0.014 + .35 +1.4	94a	91a	91a	84abc
carfentrazone-ethyl + 2,4-DB + dimethenamid-P	0.014 + .35 + 2.1	95a	95a	95a	76c
Lactofen + S-metolachlor	0.22 + 1.4	90ab	95a	70b	84abc
Lactofen + dimethenamid-P	0.22 + 2.1	84b	95a	58c	80bc
Paraquat + S-metolachlor	0.56 + 1.4	96a	93a	94a	93a
Paraquat + dimethenamid-P	0.56 + 2.1	95a	95a	93a	89ab

[1] Means within a column at each location followed by the same letter are not significantly different at the 0.05 level.
[2] All applications were made with 0.25% volume/volume nonionic surfactant.

Table 3.5. Weed control with PRE treatments, combined with POST treatments, at Caddo County, West in 2006.

		Caddo County West 18 DAT[1]			
Herbicide[2]	Rate	CYPES	PANTE	IPOHG	VEEEN
	kg ai/ha	%			
carfentrazone-ethyl + 2,4-DB + S-metolachlor	0.014 + .35 +1.4	91a	29ab	89a	90a
carfentrazone-ethyl + 2,4-DB + dimethenamid-P	0.014 + .35 + 2.1	93a	30ab	89a	91a
Lactofen + S-metolachlor	0.22 + 1.4	91a	24b	60b	53c
Lactofen + dimethenamid-P	0.22 + 2.1	89a	25b	70ab	58bc
Paraquat + S-metolachlor	0.56 + 1.4	93a	58a	85ab	83abc
Paraquat + dimethenamid-P	0.56 + 2.1	89a	60a	88a	88ab

[1] Means within a column at each location followed by the same letter are not significantly different at the 0.05 level.
[2] All applications were made with 0.25% volume/volume nonionic surfactant.

Table 3.6. Effects of PRE treatments, combined with POST treatments on peanut yield, at Caddo East and West, Custer, and Beckham Counties in 2006.

Herbicide[2]	Rate	Yield[1]			
		Caddo County East	Caddo County West	Custer County	Beckham County
	kg ai/ha	kg/ha			
Untreated Check	---------	82a	162a	316a	409a
carfentrazone-ethyl + 2,4-DB + S-metolachlor	0.014 + .35 +1.4	140a	246a	347a	490a
carfentrazone-ethyl + 2,4-DB + dimethenamid-P	0.014 + .35 + 2.1	122a	270a	339a	483a
Lactofen + S-metolachlor	0.22 + 1.4	106a	188a	425a	449a
Lactofen + dimethenamid-P	0.22 + 2.1	94a	262a	323a	440a
Paraquat + S-metolachlor	0.56 + 1.4	91a	234a	362a	377a
Paraquat + dimethenamid-P	0.56 + 2.1	123a	271a	312a	413a

[1] Means within a column at each location followed by the same letter are not significantly different at the 0.05 level.
[2] All applications were made with 0.25% volume/volume nonionic surfactant.

VITA

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Master of Science

Thesis: ALTERNATIVE CONTROL PRACTICES FOR A*MARANTHUS PALMERI* RESISTANT TO ACETOLACTATE SYNTHASE INHIBITING HERBICIDES IN OKLAHOMA PEANUT FIELDS

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Pages in Study: 56 Candidate for the Degree of Master of Science

Major Field: Plant and Soil Science

Scope and Method of Study: Chapter I: Palmer amaranth populations across western Oklahoma are developing resistance to acetolactate synthase (ALS) inhibiting herbicides. Trials were established to evaluate ALS resistant pigweed control, in no-till and strip-till systems with various levels of herbicides imposed. Chapter II: *Amaranthus* is the genus of the pigweed family. The word is derived from the Greek word, amarantus, which means "everlasting". Research has shown significant yield reduction from the competition of the *Amaranthus* sp. This study was conducted to evaluate peanut injury and herbicide efficacy of POST herbicide applications. Chapter III: Palmer amaranth is one of the most troublesome weeds in Oklahoma peanut production today due to its rapid growth rate, high competitiveness, long germination period, and high seed production potential. Trials were established to evaluate tank mixes of residual and contact-type herbicide applications on Palmer amaranth control and peanut yields.

Findings and Conclusions: Chapter I: Only the herbicide treatment effect was significant for AMAPA (*Amaranthus palmeri* S. Wats.) control and peanut yield. Pendimethalin EC (1.1 kg ai/ha), controlled AMAPA 52 and 89% compared to pendimethalin PE (1.1 kg ai/ha) which controlled AMAPA 28 and 72% 53 DAT at Beckham and Caddo Counties respectively. Although not significant, flumioxazin and sequential applications of S-metolachlor consistently provided the best control of AMAPA across all three locations. Chapter II: Paraquat (0.56 kg ai/ha) and paraquat (0.84 kg ai/ha) which is 50% over the labeled rate of paraquat tank mixed with S-metolachlor (1.4 kg ai/ha), was not significantly different at 36 DAT. Even when paraquat rates were increased 50% over the label rate, there was no significant peanut injury visible, thus allowing us to control AMAPA better than with lower rates. Chapter III: In 2005, all treatments at Caddo and Beckham Counties controlled AMAPA at least 86% 30 DAT when compared to the untreated check. These data indicate a need for PRE herbicides to be tank mixed with POST herbicides to achieve acceptable weed control.

ADVISER'S APPROVAL: Dr. Case R. Medlin