Weed Control Programs in Peanut (*Arachis hypogaea*) With Diclosulam and Ethalfluralin Combinations

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ABSTRACT

Field studies were conducted during the 1998 and 1999 growing seasons to evaluate diclosulam (Strongarm) alone and in combination with ethalfluralin (Sonalan) for devil's-claw, Palmer amaranth, pitted morningglory, Texas panicum, and yellow nutsedge control. Diclosulam alone applied preplant incorporated, preemergence, or postemergence controlled Palmer amaranth and pitted morningglory greater than 81%, devil's-claw at least 80%, Texas panicum 33 to 97%, and yellow nutsedge 48 to 88% four weeks after treatment (WAT). When ethalfluralin was applied in combination with diclosulam, early-season (4 WAT) Palmer amaranth was controlled at least 97%, devil's-claw was controlled at least 87%, pitted morningglory was controlled greater than 90%, Texas panicum was controlled greater than 80%, and yellow nutsedge control was at least 72%. When rated 14 WAT, ethalfluralin applied in combination with or followed by diclosulam controlled Palmer amaranth and pitted morningglory at least 87%, devil's-claw 100%, and yellow nutsedge at least 86%. Diclosulam alone controlled no greater than 79% yellow nutsedge regardless of rate or application method. Texas panicum control (14 WAT) with ethalfluralin in combination with or followed by diclosulam or diclosulam alone was less than 90% regardless of rate or application method.

KEYWORDS: *Amaranthus palmeri* S. Wats, *Cyperus esculentus* L., devil's-claw, *Ipomoea lacunose* L., Palmer amaranth, *Panicum texanum* Buckl., pitted morningglory, preemergence, preplant incorporated, *Proboscidea louisianica* (Mill.) Thellung, postemergence. Texas panicum, yellow nutsedge.

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INTRODUCTION

Broadleaf weeds such as devil's-claw [*Proboscidea louisianica* (Mill.) Thellung], Palmer amaranth (*Amaranthus palmeri* S. Wats), and pitted morningglory (*Ipomoea lacunosa* L.) are a continuing problem in certain peanut growing areas of the southwestern U.S. Dowler (1998) ranks pigweed spp., morningglory spp., Texas panicum (*Panicum texanum* Buckl.), and yellow nutsedge (*Cyperus esculentus* L.) among the ten most common and troublesome weeds in Texas peanut, and these weeds are found in all peanut growing areas of the state (Grichar et al. 1999).

Control of many broadleaf weeds and annual grasses in Texas can be achieved with a preplant application of a dinitroaniline herbicide such as trifluralin (Treflan), pendimethalin (Prowl), or ethalfluralin (Sonalan) (Wilcut et al. 1995). However, weeds such as Palmer amaranth and Texas panicum can escape control due to extremely high weed populations, improper soil incorporation, large seed size, or an inadequate herbicide rate (Grichar and Colburn 1996). Dinitroaniline herbicides do not adequately control devil's-claw, pitted morningglory, or yellow nutsedge (Wilcut et al. 1995).

Imazapic (Cadre) provides more effective control of yellow nutsedge than any of the currently registered herbicides in peanut including imazethapyr (Pursuit) (Grichar et al. 1992; Richburg et al. 1995; Dotray and Keeling 1997). Imazapic also has a longer period of residual weed control than imazethapyr when applied postemergence (POST) (Grichar et al. 1992). The 18-mo crop rotation restriction following imidazolinone herbicide use on peanut with cotton (*Gossypium hirsutum* L.) limits the use of the imidazolinone herbicides, especially in areas where cotton follows peanut in a rotation (Grichar et al. 1999; Richburg et al. 1994; Matocha et al. 2003).

Diclosulam is a triazolopyrimidine sulfonanilide herbicide registered for use in soybean [*Glycine max* (L.) Merr.] and peanut (Barnes et al. 1998; Bailey et al. 1999a,b; Smith et al. 1998; Grichar et al. 1999; Grey et al. 2001) and controls broadleaf weeds and nutsedge species. Diclosulam applied preplant incorporated (PPI) offers less risk and more consistent control than preemergence (PRE) applications which require rainfall or irrigation to move the herbicide into the soil where weed seed germination occurs (Grey et al. 2001).

Peanut varieties have shown excellent tolerance to diclosulam (Bailey et al. 1999b, 2000; Bailey and Wilcut 2002; Main et al. 2000, 2002; Price et al. 2002). Price et al. (2002) reported that diclosulam systems provided yields equivalent to metolachlor (Dual) followed by imazapic. Bailey and Wilcut (2002) reported that peanut yields were indicative of the level of weed management provided by diclosulam-containing systems that included POST herbicides. Main et al. (2002) reported that 'Georgia Green', 'C-99R', and 'MDR-98' were not affected by diclosulam applied PPI at 0.3, 0.5, or 0.88 oz product/A.

In south Texas, no problems have been reported with diclosulam (Grichar et al. 1999). However, in west Texas, diclosulam has caused peanut stunting and reduction in yield (Grichar et al. 2001; Karnei et al. 2001, 2002; Murphree et al. 2003). Karnei et al. (2001, 2002) reported that, under weed-free conditions, diclosulam at 0.88 oz product/A caused 8 to 10% late-season peanut injury while rates lower than 0.88 oz product/A resulted in less than 3% injury. They also reported that plots treated with diclosulam applied PPI at 0.88 oz/A yielded 480 lbs/A less than diclosulam at 0.3 oz product/A. While the untreated check plot yielded greater than 3000 lbs/A, plots treated with diclosulam at 0.4 oz product/A applied PPI produced 2400 lbs/A, and plots treated with

diclosulam at the same rate applied PRE yielded 2600 lbs/A. In growth chamber studies, Grichar et al. (2001) reported that diclosulam rate was a factor in reduced peanut germination in only one of three studies. In that study, germination decreased as diclosulam rate increased. They concluded that poor seed quality could reduce peanut seed germination. Murphree et al. (2003) reported diclosulam applied PRE at 0.44 oz product/A injured peanut 15 to 40% when rated 14 days after treatment (DAT) in 2001, but injury was less than 8% in 2002. When rated late-season, all injury decreased to less than 5% and peanut yields were not affected.

The objective of this research was to evaluate weed control with diclosulam applied PPI, PRE, or POST alone or in combination with ethalfluralin compared to the commercial standard of ethalfluralin and imazapic in different peanut growing areas of Texas.

MATERIALS AND METHODS

Field studies were conducted during the 1998 and 1999 growing season at Texas Agricultural Experiment Stations near Yoakum and Lubbock, TX. Soil type at the Yoakum, Texas site was a Tremona loamy fine sand (thermic Aquic Arenic Palenstalf) with less than 1% organic matter and pH 7.2 while the soil type at Lubbock, Texas was an Amarillo sandy clay loam (fine-loamy, mixed, thermic Aridic Paleustalfs) with less than 1% organic matter and pH 7.8.

The experimental design was a randomized complete block replicated four times at Yoakum and three times at Lubbock. A factorial arrangement of treatments was used. Ethalfluralin (Sonalan HFP, Dow AgroSciences) or no ethalfluralin, diclosulam (Strongarm 84WG, Dow AgroSciences) rate, and diclosulam application method were factors at Yoakum and ethalfluralin or no ethalfluralin and diclosulam rates were factors at Lubbock . Plots, two rows 25 ft long spaced 36 in apart at Yoakum and four rows 30 ft long spaced 38 in apart at Lubbock, contained natural infestations of pitted morningglory (densities greater than 2 plants/ft^2), Texas panicum (densities were 1 to 2 plants/ft^2), yellow nutsedge (densities were 2 to 3 plants/ft^2), Palmer amaranth (densities were 2 to 3 plants/ft^2), and devil's-claw (densities were 0.5 plants/ft^2).

PPI applications of diclosulam and ethalfluralin were incorporated with a tractor-driven power tiller to a depth of 2 inch at Yoakum or a spring tooth harrow field cultivator to a depth of 3 inch at Lubbock. Preemergence herbicides were applied immediately after peanuts were planted. Postemergence herbicides were applied when Texas panicum was at 4 to 6 leaf stage while pitted morningglory and yellow nutsedge was at the 10 to 12 leaf stage (approximately 3 wk after PPI application) at Yoakum. At Lubbock, imazapic (Cadre 70DG, BASF Corp.) was applied POST when Palmer amaranth and devil's-claw were at the 2 to 8 leaf stage. Herbicides were applied with a CO_2 backpack sprayer using Teejet 11002 (Spraying Systems Co., Wheaton, IL 60189) flat fan nozzles which delivered a spray volume of 20 gal/A at 30 PSI at Yoakum or Teejet 80015 flat fan nozzles which delivered 10 gal/A at 25 PSI at Lubbock. Postemergence applications of diclosulam and imazapic included an organosilicone based surfactant (Kinetic HV, Helena Chemical Co., Memphis, TN 38119) at 0.25% (v/v) at Yoakum or crop oil concentrate (Agridex, Helena Chemical Co., Memphis, TN 38119) at 1% (v/v) at Lubbock.

Herbicide treatments at Yoakum included ethalfluralin at 2.0 pt/A in combination with diclosulam at 0.3 or 0.44 oz product/A applied PPI, ethalfluralin

applied PPI followed by (fb) diclosulam at 0.3 and 0.44 oz product/A applied PRE or POST or diclosulam alone at 0.3 or 0.44 oz product/A applied PPI, PRE, or POST. Ethalfluralin at 2.0 pt/A applied alone or ethalfluralin at 2.0 pt/A applied PPI fb imazapic at 1.44 oz product/A applied POST were the herbicide standards (Table 1). At Lubbock, diclosulam was applied PPI at 0.3, 0.44, or 0.88 oz product/A alone or in combination with ethalfluralin at 2.0 pt/A. Ethalfluralin fb imazapic at 1.44 oz product/A applied POST was the herbicide standard (Table 2). An untreated check was included at both locations.

Georgia Green was planted both years at Yoakum and Tamrun 88 (1997) and AT 120 (1998) was planted at Lubbock. Seeding rates at both locations were 90 lb/A with a planting depth of approximately 1.5 to 2.0 inch. Weed control was visually estimated approximately 4 and 14 wk after POST application using a scale of 0 (no weed control) to 100 (complete weed control). Peanut injury (stunting) was rated at Lubbock 3 wk after PPI treatment on a scale of 0 (no peanut stunting) to 100 (complete peanut death). All weed control data was subjected to ANOVA to test the effects of herbicide, diclosulam rate, and timing of herbicide application. Means were compared with the appropriate Fisher's protected LSD test at the 5% level of probability. Peanut yields were not determined due to difficulty in digging plots because of the high weed populations and reluctance to use equipment under such weedy conditions.

RESULTS AND DISCUSSION

At Lubbock, results from each year are presented separately, with the exception of Palmer amaranth ratings taken four weeks after treatment (WAT), due to a treatment by year interactions. Since there was no significant year by treatment interactions at Yoakum, all weed control data were combined over years.

Peanut Stunting. At Lubbock in 1998, peanut injury (8%) was observed 3 WAT following diclosulam at 0.88 oz product/A with or without ethalfluralin (Table 1). In 1999, peanut injury was noted with diclosulam at 0.88 oz/A with or without ethalfluralin or ethalfluralin fb imazapic applied POST. No injury was observed 14 WAT in either year (data not shown). Peanut stunting due to diclosulam was not noted at Yoakum (data not shown).

Palmer Amaranth Control. Combined over years, Palmer amaranth was controlled 97 to 100% by all herbicide treatments when rated 4 WAT (Table 1). In 1998, at 14 WAT, diclosulam alone at 0.3 or 0.44 oz product/A and ethalfluralin fb imazapic applied POST controlled Palmer amaranth less than 88% while ethalfluralin fb diclosulam at any rate provided at least 98% control. However, in 1999, all herbicide treatments controlled Palmer amaranth at least 93%.

Table 1. Peanut injury and weed control near Lubbock, Texas with diclosulam applied preplant incorporated.[a]

Herbicide and rate		Peanut stunt		Control AMAPA[b]			PROLO			
		3 WAT		4 WAT	14 WAT		4 WAT		14 WAT	
Ethalfluralin	Diclosulam	1998	1999		1998	1999	1998	1999	1998	1999
------Product/A-------		----------%----------								
2.0 pt	0	0	0	97	90	97	77	0	0	0
	0.3 oz	0	0	98	99	100	97	90	100	100
	0.44 oz	0	0	100	98	100	97	87	100	100
	0.88 oz	8	4	100	99	100	97	92	100	100
0	0.3 oz	0	0	100	81	93	83	80	93	100
	0.44 oz	0	0	97	87	97	94	82	97	92
	0.88 oz	8	2	100	91	98	92	89	98	85
2.0 pt	Imazapic[c]	0	4	99	78	100	98	100	100	100
LSD (0.05)		3	2	NS	9	6	11	7	6	11

[a]Bayer code for weeds and abbreviations: AMAPA, Palmer amaranth; PROLO, devil's-claw; NS, not significant; WAT, weeks after treatment.

[b] 4 WAT ratings combined over years.

[c]Imazapic at 1.44 oz/A applied postemergence after ethalfluralin applied preplant incorporated.

Devil's-claw Control.

Devil's-claw control 4 WAT in 1998 was at least 92% (Table 1) with all herbicide treatments except diclosulam alone at 0.3 oz product/A (83%) and ethalfluralin alone (77%). In 1999, 4 WAT, diclosulam alone controlled devil's-claw 80 to 89% while ethalfluralin in combination with diclosulam controlled 87 to 92%. Ethalfluralin alone controlled no devil's-claw; however, ethalfluralin fb imazapic applied POST provided 100 % control.

When rated late-season in 1998, ethalfluralin in combination with diclosulam or fb by imazapic applied POST provided complete control while diclosulam alone controlled devil's-claw 93 to 98% (Table 1). In 1999, ethalfluralin in combination with diclosulam, diclosulam alone at 0.3 oz product/A, or ethalfluralin fb imazapic provided 100% control while diclosulam alone at 0.88 oz product/A devil's-claw 85%.

Pitted Morningglory Control.

There was a significant ethalfluralin by diclosulam rate by application timing interaction for pitted morningglory control at the 4 and 14 WAT ratings. When rated 4 WAT, diclosulam at 0.3 oz product/A in combination with ethalfluralin applied PPI controlled pitted morningglory 94% while PRE or POST applications of diclosulam following ethalfluralin PPI controlled pitted morningglory 91 and 98%, respectively

(Table 2). When ethalfluralin was applied in combination with or fb diclosulam at 0.44 oz product/A, pitted morningglory was controlled at least 96%.

Table 2. Weed control near Yoakum using diclosulam.[a]

Herbicide and rate			Control					
		Appl.	IPOLA		PANTE		CYPES	
Ethalfluralin	Diclosulam	timing	4 WAT[b]	14 WAT	4 WAT	14 WAT	4 WAT	14 WAT
--------Product/A--------			----------%----------					
None	0.3 oz	PPI	97	99	78	73	88	79
		PRE	93	96	97	66	80	77
		POST	94	87	33	66	58	70
	0.44 oz	PPI	94	98	85	83	84	78
		PRE	94	89	95	70	74	61
		POST	95	88	40	54	48	78
2.0 pt	0.3 oz	PPI	94	93	98	70	87	88
		PRE	91	89	81	70	83	86
		POST	98	87	97	86	72	90
	0.44 oz	PPI	96	94	97	63	96	94
		PRE	97	94	99	89	80	89
		POST	100	97	94	75	76	91
2.0 pt	None	PPI	28	32	97	95	0	0
2.0 pt	Imazapic[c]	POST	89	83	99	74	88	96
LSD (0.05)			2	3	8	23	6	17

[a]Bayer code for weeds: IPOLA, pitted morningglory; PANTE, Texas panicum; CYPES, yellow nutsedge.
[b]Abbreviations: PPI, preplant incorporate; PRE, preemergence; POST, postemergence; WAT, weeks after treatment.
[c]Imazapic at 1.44 oz/A applied POST after ethalfluralin applied PPI.

At 4 WAT, when diclosulam was applied PPI at 0.3 oz/A without ethalfluralin, pitted morningglory control was 97%, but control was less than 95% when diclosulam alone was applied PRE or POST. Diclosulam alone at 0.44 oz/A controlled pitted morningglory 94 to 95% regardless of application method. Richburg et al. (1997) reported that diclosulam controlled pitted morningglory in soybean equal to or greater than imazaquin. Grichar et al. (1999) reported that ethalfluralin plus diclosulam at 0.3 to 1.2 oz product/A applied PPI controlled pitted morningglory at least 98% regardless of rate.

When rated 14 WAT, ethalfluralin in combination with or fb diclosulam at 0.3 oz product/A controlled pitted morningglory 87 to 93% while control with ethalfluralin in combination with or fb diclosulam at 0.44 oz product/A was 94% to 97% following all diclosulam application timings (Table 2). Without ethalfluralin, diclosulam alone at 0.3 or 0.44 oz product/A controlled pitted morningglory at least 98% when applied PPI.

Diclosulam alone applied PRE controlled pitted morninglory 96% at the 0.3 oz product/A and 89% at the 0.44 oz product/A rate. Diclosulam alone applied POST at either rate controlled morningglory no better than 88%. A PPI application of ethalfluralin alone controlled pitted morningglory 32% while ethalfluralin fb imazapic applied POST controlled pitted morningglory 83%.

Bailey et al. (1999a,b) reported that ethalfluralin plus diclosulam applied PPI at rates up to 0.44 oz product/A controlled pitted morningglory greater than 90%. They also reported that pitted morningglory was controlled at least 93% with imazapic-containing systems.

Texas Panicum Control.

When rated 4 WAT, diclosulam alone applied PPI at 0.3 and 0.44 oz product/A controlled Texas panicum 78 and 85%, respectively. Diclosulam alone at 0.3 and 0.44 oz/A applied PRE controlled Texas panicum at least 95% while POST applications controlled no greater than 40%. Ethalfluralin in combination with or fb diclosulam at 0.3 or 0.44 oz product/A controlled Texas panicum greater than 90% except for ethalfluralin applied PPI fb diclosulam applied PRE at 0.3 oz product/A which controlled 81% (Table 2). Generally, control of annual grasses can be achieved with PPI applications of dinitroaniline herbicides (Wilcut et al. 1995). Wilcut et al. (1987a,b) reported that the minimum input necessary to achieve consistent Texas panicum control was a dinitroaniline herbicide combined with at least one cultivation.

When rated 14 WAT, diclosulam alone at 0.3 oz/A controlled Texas panicum 66 to 73% while diclosulam alone at 0.44 oz/A controlled Texas panicum 54 to 83% regardless of application method (Table 2). In other studies, diclosulam did not control annual grasses (Bailey et al. 1999a,b; Grey et al. 2001; Grichar et al. 1999). Ethalfluralin in combination with or fb diclosulam at 0.3 oz/A controlled Texas panicum 70 to 86% regardless of application method. Ethalfluralin in combination with diclosulam at 0.44 oz/A applied PPI controlled Texas panicum 63% while ethalfluralin fb diclosulam at 0.44 oz/A applied PRE or POST controlled Texas panicum 89 and 75%, respectively.

Yellow Nutsedge Control.

When rated 4 WAT, diclosulam alone at 0.3 or 0.44 oz product/A applied PPI or PRE controlled yellow nutsedge 74 to 88% while diclosulam applied POST at those rates controlled yellow nutsedge less than 60%. Ethalfluralin in combination with or fb diclosulam applied PRE at 0.3 oz/A controlled yellow nutsedge 83 to 87% while diclosulam at 0.44 oz product/A applied in combination with or following ethalfluralin controlled yellow nutsedge 80 to 96% (Table 2). Ethalfluralin fb diclosulam at either rate applied POST controlled no greater than 76% yellow nutsedge early season. Imazapic applied POST following ethalfluralin controlled yellow nutsedge 88%. Grichar et al. (1999) reported that diclosulam at 0.2 oz product/A applied PPI provided inconsistent control of yellow nutsedge. They also reported that diclosulam at rates greater than 0.3 oz/A controlled at least 90% yellow nutsedge. Scott et al. (2001) reported that adding diclosulam to metolachlor applied PRE improved control (99%).

When rated 14 WAT, diclosulam alone controlled less than 80% yellow nutsedge regardless of rate or application timing while ethalfluralin applied PPI fb

imazapic applied POST controlled yellow nutsedge 96% (Table 2). Ethalfluralin in combination with or fb diclosulam applied PPI or PRE controlled yellow nutsedge at least 86% while POST applications of diclosulam following ethalfluralin controlled yellow nutsedge at least 90%. Wilcut et al. (1999) determined that soil applications of diclosulam resulted in reduced shoot dry weights of both yellow and purple nutsedge (*Cyperus rotundus* L.). Grey et al. (2001) reported that increasing the rate of diclosulam applied PPI suppressed yellow nutsedge; however, additional POST herbicides were needed for acceptable control.

CONCLUSION

These data show that diclosulam offers peanut growers another option for use in their herbicide programs. Devil's-claw, Palmer amaranth, pitted morningglory, Texas panicum, and yellow nutsedge control with ethalfluralin and diclosulam soil-applied at 0.3 and 0.44 oz product/A was similar to the commercial standard, imazapic applied POST, which is widely used in the Texas peanut growing regions. POST applications of diclosulam controlled pitted morningglory as well as soil-applied applications. However, POST applications of diclosulam were inconsistent for yellow nutsedge and Texas panicum control.

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