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ARTICLE

Peanut Cultivar Response to Diclosulam in the Southwest Peanut Growing Region

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ABSTRACT

Field experiments were conducted in the south Texas and Texas High Plains area during the 2018 through 2020 growing seasons and in southwestern Oklahoma in 2020 to evaluate runner peanut cultivars (Georgia-13M, Georgia-09B) and the Spanish cultivar (Ole´) tolerance to diclosulam at 0.026 (the manufacture's recommended use rate) and 0.052 (twice the manufacture's recommended use rate) kg ai/ha applied preemergence (PRE) or peanut cracking (CRACK). No diclosulam injury was noted in south Texas; however, in the Texas High Plains and Oklahoma locations significant stunting was noted with diclosulam applied PRE especially under sprinkler irrigation. In 2018 at the High Plains location, under furrow irrigation, no peanut stunting was noted. In 2019 and 2020, under sprinkler irrigation, diclosulam at 0.026 and 0.052 kg/ha applied PRE resulted in early-season stunting of 18 to 59% in both Oklahoma and the Texas High Plains. No late-season stunting was noted in Oklahoma; however, up to 20% stunting was still visible at the Texas High Plains location. No yield differences were noted in south Texas or the High Plains region in 2018 or 2020; however, in 2019 at the High Plains location, peanut yield decreased as diclosulam rate increased but application timing had no effect. At the Oklahoma location, application timing and rate effect were noted. Diclosulam applied PRE and the high rate of diclosulam reduced peanut yield. Issues still exist with diclosulam in the southwest peanut growing areas as seen previously in 2000 despite the different varieties planted. There may be opportunities to utilize diclosulam postemergence (POST) since peanut injury was 5% or less and yields were not reduced when applied CRACK.

INTRODUCTION

Weeds such as Palmer amaranth (*Amaranthus palmeri* S. Wats), pitted morningglory (*Ipomoea lacunosa* L.), purple nutsedge (*Cyperus rotundus* L.), smellmelon (*Cucumis melo* L.) Texas millet [*Urochloa texana* (Buckl.)], and yellow nutsedge (*Cyperus esculentus* L.) are a continuing problem in peanut (*Arachis hypogaea* L.) growing areas of the southwestern US (Grichar and Dotray, 2013; Grichar *et al.*, 2019; Baughman *et al.*, 2018; Dotray *et al.*, 2018). These weeds can be found in all peanut growing areas of this region (Grichar *et al.*, 1999).

Control of many broadleaf weeds and annual grasses can be obtained with a preplant application of a dinitroaniline herbicide such as ethalfluralin (Sonalan®), pendimethalin (Prowl® or Prowl H_20®), or trifluralin (Treflan®) (Wilcut *et al.,* 1995). However, weeds such as Palmer amaranth and Texas millet can escape control due to extremely high weed populations, improper soil incorporation, large seed size, and/or an inadequate herbicide rate (Wilcut *et al.,* 1995; Grichar and Colburn, 1996). Dinitroaniline herbicides alone do not adequately control any of these weeds for the entire growing season (Wilcut *et al.*, 1995; Grichar *et al.*, 1999; Grichar and Dotray, 2013; Baughman *et al.*, 2018; Dotray *et al.*, 2018; Grichar *et al.*, 2019).

Diclosulam was labeled for use in peanut in 2000 in all states but was restricted from use in New Mexico, Oklahoma, and Texas in 2001 (Anonymous, 2017). This herbicide is a triazolopyrimidine sulfonanilide herbicide developed for use in soybean (*Glycine max* L.) and peanut (Gander *et al.*, 1997; Sheppard *et al.*, 1997). As a preplant incorporated (PPI) or preemergence (PRE) treatment, diclosulam controls many weeds found in soybean and peanut, including common cocklebur (*Xanthium strumarium* L.), morningglory spp. (*Ipomoea* spp.), common ragweed (*Ambrosia artemisiifolia* L.), pigweed spp. (*Amaranthus* spp.), common lambsquarters (*Chenopodim album* L.), prickly sida (*Sida spinosa* L.), Florida beggarweed [*Desmodium tortuosum* (Sw) DC.], bristly starbur (*Acanthospermum hispidum* DC.), and yellow nutsedge (Braxton *et al.*, 1997; Richburg *et al.*, 1997; Sheppard *et al.*, 1997; Prostko *et al.*, 1999; Wilcut *et al.,* 1999; Bailey *et al.*, 2002; Main *et al.*, 2005; Grichar *et al.*, 2008; Anonymous, 2017).

Yellow nutsedge control has been reported to vary with diclosulam rate and method of application (Grichar *et al.*, 1999; Bailey *et al.*, 1999a; b). Diclosulam at increased rates provided 89% control of yellow nutsedge but was less consistent when applied postemergence (POST) (Langston *et al.*, 1997; Grichar *et al.*, 1999). When diclosulam was added to metolachlor PRE, yellow nutsedge control was greater than 95% (Scott *et al.*, 2001). Grey *et al.* (2001) reported that increased rates of diclosulam applied PPI from 0.009 to 0.052 kg ai/ha resulted in increased yellow nutsedge control but additional POST herbicides were needed for acceptable control.

In earlier work in south Texas, no problems were reported with diclosulam (Grichar *et al.*, 1999). However, in west Texas, diclosulam 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 0.062 kg ai/ha caused 8 to 10% late-season peanut injury while rates lower than 0.062 kg ai/ha resulted in less than 3% injury. They also reported that plots treated with diclosulam applied PPI at 0.062 kg ai/ha yielded 538 kg/ha less than diclosulam at 0.021 kg ai/ha. While the untreated check plot yielded greater than 3300 kg/ha, plots treated with diclosulam at 0.028 kg ai/ha applied PPI produced 2690 kg/ha, and plots treated with diclosulam at the same rate applied PRE yielded 2914 kg/ha. 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 0.031 kg ai/ha 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.

Research is limited since the early 2000's in Texas and Oklahoma evaluating peanut variety response to diclosulam. Therefore, the objective of this research was to evaluate some of the newer released peanut varieties for tolerance to diclosulam in the Texas and Oklahoma peanut growing areas.

MATERIALS AND METHODS

Peanut tolerance studies were conducted at the Texas A&M AgriLife Research site in south Texas near Yoakum (29.0369° N, 97.2616° W), in the Texas High Plains during the 2018 season near Lubbock at the Texas A&M AgriLife Research and Extension Center (33.6939° N, 101.8192° W) and in 2019 and 2020 in a producer's field in Gaines County near Seminole (32.7429° N, 102.8253° W). The study in Oklahoma was conducted only in 2020 at the Oklahoma State University Caddo Research Station near Ft. Cobb (35.091° N, 98.275°W) in southwestern Oklahoma. Soils at Yoakum were a Denhawken sandy clay loam (fine, smectitic, hyperthermic, Vertic Haplustepts) with less than 1.0 % organic matter and pH 7.6 while near Lubbock soils were a Acuff loam (fine-loamy, mixed, superactive, thermic Aridic Paleustalls) with 1% organic matter and a pH 7.5 while soils at the Seminole location were a Patricia loamy fine sand (fine-loamy, mixed, superactive, thermic Aridic Paleustalfs) with 1.4% organic matter and a pH 7.9. Soils at Ft. Cobb were a Cobb fine sandy loam (fine-loamy, mixed, active, thermic Typic Haplustalfs) with less than 1% organic matter and a pH 7.3.

Treatments consisted of a factorial arrangement of two herbicide treatments (diclosulam at 0.026 or 0.052 kg ai/ha) and two application timings [PRE or at peanut cracking (CRACK)]. The CRACK application was applied 7 to 13 days after planting depending on location. An untreated check was included in each study and each treatment was replicated three to four times depending on location. Specifics of each study can be seen in Table 1.

Table 1. Variables associated with diclosulam study in Texas and Oklahoma.

	South Texas			Texas High Plains			Oklahoma
Variable	2018	2019	2020	2018	2019	2020	2020
Location	Yoakum	Yoakum	Yoakum	Lubbock	Seminole	Seminole	Ft. Cobb
Coordinates	29.2770o N -97.1245o W	29.2671o N -97.0541o W	29.2770o N -97.1245o W	33.6939oN -101.8192o W	32.7324o N -102.8767o W	32.7521o N -102.7872o W	35.0910o N -98.2745o W
Planting date	June 26	June 24	June 17	April 26	April 30	April 28	May 6
Variety	Georgia-13M	Georgia-09B	Georgia-09B	Georgia-09B	Georgia-09B	Georgia-09B	OLe´
Application Sprayer type	CO2 backpack	CO2 backpack	CO2 backpack	CO2 backpack	CO2 backpack	CO2 backpack	CO2 backpack

Table 1. Variables associated with diclosulam study in Texas and Oklahoma.

	South Texas			Texas High Plains			Oklahoma
Variable	2018	2019	2020	2018	2019	2020	2020
Location	Yoakum	Yoakum	Yoakum	Lubbock	Seminole	Seminole	Ft. Cobb
Spray pressure (kPa)	180	180	180	198	198	180	168
Nozzle type	Flat fan	Flat fan	Flat fan	Flat fan	Flat fan	Flat fan	Flat fan
Nozzles tips	DG 11002	DG 11002	DG 11002	Teejet 11002	Teejet 11002	Teejet 11002	TTI 110015
Spray volume (L ha-1)	187	187	187	140	140	140	112
PRE	July 1	June 26	June 19	April 26	May 1	April 28	May 6
CRACK	July 8	July 1	June 30	May 8	May 13	May 6	May 19

Peanut cultivars evaluated were those commonly grown in each production area. In south Texas, Georgia-13M (Branch, 2014) was evaluated in 2018 while Georgia-09B (Branch, 2010) was evaluated in 2019 and 2020 while at the High Plains locations Georgia-09B was evaluated all 3 years. The Spanish cultivar OLe´ (Anonymous, 2015) was evaluated at the Ft. Cobb location.

Each plot consisted of two rows spaced 97 cm apart and 7.6 m long at Yoakum. At the Texas High Plains locations plot size was 4 rows spaced 102 cm apart and 7.6 m long in 2018 and 9.1 m long in 2019 and 2020 but only the center two rows received the herbicide treatment. The Oklahoma location consisted of 2 rows spaced 91 cm apart and 7.6 m long. Traditional production practices were used to maximize peanut growth, development, and yield. Plots at the Texas locations received either ethalfluralin or pendimethalin applied PPI to control early season weeds. In 2018 at the High Plains location, lactofen plus *S*-metolachlor was applied 30 days after planting as a blanket treatment over the entire test area. In south Texas, clethodim and 2,4-DB were used POST to control any late season weed infestations. Hand-weeding was used exclusively in Oklahoma and only at the Texas locations if necessary. Insecticides were not needed at any location in any year. Herbicides for the small plots were applied using water as a carrier with a CO_2-pressurized backpack sprayer (Table 1).

At Yoakum, lateral hand moved irrigation lines were used and irrigation was applied as needed throughout the growing season. At the Lubbock location in 2018, furrow irrigation was applied as needed while in 2019 and 2020 at the Seminole location and at the Ft. Cobb location, a center pivot irrigation system was used to apply water as needed.

Peanut stunting was based on visual subjective estimates using a scale of 0 (no peanut stunting) to 100 (peanut death). Peanut yield was determined by digging the pods based on maturity of non-treated control plots, air-drying in the field for 6 to 10 days, and harvesting with a small-plot thresher. Yield samples were cleaned and adjusted to 10% moisture. Pod, shell, and peanut kernal weight were determined from each sample. Grades [percent sound mature kernels (SMK) plus sound splits (SS)] were determined for a 200-g pod sample from each plot following procedures described by the Federal-State Inspection Service (Anonymous, 2019). Grade data was collected at Yoakum and the High Plains locations.

Data for percentage of peanut stunting were transformed to the arcsine square root prior to analysis; however, nontransformed means are presented because arscine transformation did not affect interpretation of the data. Data were subjected to ANOVA and analyzed using the SAS PROC MIXED procedure 23 (SAS, 2019). Treatment means were separated using Fisher's Protected LSD at $P < 0.05$. The untreated check was used for peanut yield and grade calculation comparison and as a visual comparison for stunting. However, the results from the untreated check plots for stunting were not included in that analysis but were included in peanut yield and grade analysis.

RESULTS AND DISCUSSION

Peanut injury (plant stunting) was estimated visually throughout the growing season at all locations, however, only the 30 and 90 days after planting (DAP) evaluations are presented.

Stunting.

Stunting was not observed in any year at the Yoakum location or in 2018 at the Lubbock location (data not shown). In 2018 at the Lubbock location, furrow irrigation was used to apply water as needed and this limited herbicide movement to the peanut plant while in 2019 and 2020 the plots were located in a field with an overhead center-pivot irrigation system which readily moved the herbicide down to the peanut root system. The south Texas results are similar to that seen in previous studies with little to no injury from diclosulam applications (Grichar *et al*., 1999; 2008)

At Seminole in 2019 at the 30 DAP application, there was a diclosulam rate by application timing interaction (Table 2). Diclosulam applied PRE at 0.026 or 0.052 kg/ha resulted in 18 and 36% stunting while diclosulam at 0.026 or 0.052 kg/ha applied at CRACK caused 0 and 4% stunt, respectively. In

2020 at the 30 DAP evaluation, there was not a diclosulam rate by application timing interaction although the diclosulam rate of 0.026 kg/ha resulted in 24% stunting while the diclosulam rate of 0.052 kg/ha resulted in 34% stunt (Table 3). The PRE application caused 59% stunting compared with no stunting seen with the at CRACK diclosulam application. The 90 DAP evaluation from 2019 and 2020 was combined over years due to a lack of rate by timing by year interaction (Table 2). Diclosulam at 0.052 kg/ha applied PRE resulted in 20% stunting while either diclosulam at 0.026 kg/ha applied PRE or at CRACK or diclosulam at 0.052 kg/ha applied at CRACK resulted in < 5% stunting.

Table 2. Peanut stunting, yield, and grade response to diclosulam[ab].

			Seminole		Yoakum	Lubbock	Seminole	Yoakum
			Stunt		Yield			Grade
			2019					
Treatment	Rate	Appl timing	30	90		2018	2020	
	Kg ai ha-1		%			Kg/ha		%
Untreated	-	-	0	0	3621	1967	4423	65.1
Diclosulam	0.026	PRE	18	4	3578	1535	4026	65.3
Diclosulam		CRACK	0	2	3450	1571	3812	65.3
Diclosulam	0.052	PRE	36	20	3390	1877	4209	64.7
Diclosulam		CRACK	4	5	3653	1510	3934	66.2
LSD (0.05)			8	11	NS	NS	NS	NS

[a]Abbreviations: CRACK, when peanut plant begins to emerge from the ground; DAP, days after planting; Pre, preemergence; NS, not significant at 0.05

[b]Peanut stunt data at 90 DAP combined over years (2019, 2020). Yield data at Yoakum combined over years (2018, 2020).

[c]Grade = sound mature kernels (SMK) + splits (SS).

Table 3. Peanut response to diclosulam rates and application timings.[a]

	Seminole		Ft. Cobb		Yoakum
		Stunt			
	Yield	30 DAP		Yield	Grade[b]
	2019			2020	2019
	Kg/ha	-----------%------------		Kg/ha	%
Diclosulam rates					
Untreated	6639	0	0	6543	64.7
0.026 kg ha-1	6510	24	6	6225	65.7
0.052 kg ha-1	5829	34	8	5737	63.3
LSD (0.05)	673	5	NS	375	2.1
Application timing					
Untreated	6639	0	0	6543	64.7
PRE	6128	59	14	5492	64.8
CRACK	6209	0	0	6470	64.1
LSD (0.05)	NS	8	4	370	NS

[a] Abbreviations: DAP, days after planting; PRE, preemergence; CRACK, peanut emergence; NS, not significant at 0.05.

[b] Grade = sound mature kernels (SMK) + sound splits (SS).

In 2020 at Ft. Cobb, early-season stunting was only affected by application timing (Table 3). Diclosulam applied PRE resulted in 14% stunting with no visible stunting noted with the at CRACK application. By the 90 DAP evaluation no peanut stunting was detected (data not shown).

In earlier work, peanut injury with diclosulam at many locations was minor and transient (Bailey *et al.*, 2000; Grey *et al.*, 2001; Lancaster *et al.*, 2007; Price *et al.*, 2002); however, in the High Plains of Texas, severe injury following diclosulam was reported (Karnei *et al.*, 2001; 2002; Murphree *et al.*, 2003). In later work, diclosulam at 0.018 and 0.027 kg/ha caused 7 to 33% stunting in west Texas but peanut injury was not observed in south and central Texas (Grichar *et al.*, 2008). In recent work, Meena *et al.* (2021) reported that diclosulam at 0.022 or 0.026 kg/ha did not cause any phytotoxic symptoms and diclosulam residues were below the detection level.

Yield.

Since there was no diclosulam rate by application timing by year effect on peanut yield at Yoakum data were combined over years. No differences in yield between treatments were noted (Table 2).

No diclosulam rate by application timing effects were noted at Lubbock in 2018 or Seminole in 2020; however, there was a year effect so years are presented separately (Table 2). Yields in 2018 were extremely low due to furrow irrigation which resulted in uneven water distribution to the peanut plants (author's personal observations). In 2019 diclosulam application timing did not have an effect on yield (Table 3). However, peanut yield decreased as diclosulam rate increased.

At the Ft. Cobb location, a diclosulam rate and application timing effect were noted (Table 3). As diclosulam rate increased peanut yield decreased and the PRE application greatly reduced yield when compared to the CRACK application.

In previous work in the High Plains region of Texas under yellow nutsedge pressure, diclosulam applied PRE at 0.018 kg/ha resulted in 11 to 21% injury and diclosulam at 0.027 kg/ha resulted in 18 to 33% injury but no yield differences were noted from the untreated check. In south Texas with diclosulam at either 0.009, 0.018, or 0.023 kg/ha applied PPI, PRE, or POST peanut yields increased over the untreated check with all diclosulam treatments except diclosulam applied PPI at 0.009 kg/ha (Grichar *et al.*, 2008). In recent work in India, Menna *et al.* (2021) reported no negative yield response whenusing diclosulam at 0.022 and 0.026 kg/ha. Earlier work in the Southeastern US has shown no negative yield response when using diclosulam (Bailey *et al.*, 1999; Everman *et al.*, 2006; Lancaster *et al.*, 2007; Main *et al.*, 2002). Bailey *et al.* (1999a) reported excellent tolerance to diclosulam at 0.017, 0.026, or 0.035 kg/ha while Lancaster *et al.* (2007) reported that imazapic treatments resulted in peanut yields greater than diclosulam treatments at 0.009 and 0.051 kg/ha but this difference in yield was more likely due to weed interference, nonvisible crop injury, or some other factor. Everman *et al.* (2006) reported, under weed-free conditions that diclosulam applied POST at 0.004 to 0.027 kg/ha did not adversely affect peanut yield.

Grade.

At Yoakum, no diclosulam rate by application by year interaction were noted in 2018 or 2020; therefore, that data is combined over years with no differences noted (Table 2). However in 2019, diclosulam rate did have an effect on grade with the grade decreasing as diclosulam rate increased. At the High Plains location, no interactions were noted; therefore, data were combined over years with no differences noted. No other studies could be found that reported on diclosulam effect on peanut grade.

CONCLUSIONS

The results of these studies indicate that diclosulam issues still exist in the Texas and Oklahoma peanut growing regions. Although no stunting or yield effects with diclosulam were noted in south Texas, stunting and yield reductions were noted in the Texas High Plains and Oklahoma. POST applications of diclosulam reduced the chance of injury or yield reductions. Therefore, more research is needed on the conditions that are responsible for peanut injury that can be seen in certain areas of the southwestern US peanut production area. Also, more research needs to be conducted with POST applications of diclosulam that may help reduce peanut injury or yield reductions.

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