Evaluation of Diclosulam and *S*-Metolachlor Applied Preplant Incorporated in Peanut (*Arachis hypogaea*)[1]

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ABSTRACT

Four field studies were conducted at three locations in North Carolina and Virginia during 1998 and 1999 to evaluate weed control, peanut response, and peanut yield following diclosulam and *S*-metolachlor applied preplant incorporated (PPI) and in systems with postemergence (POST) commercial herbicide standards. Diclosulam PPI at 17, 26, or 35 g ai/ha alone or in mixture with *S*-metalochlor controlled smooth pigweed better than S-metolachlor followed by (fb) acifluorfen plus bentazon POST. All diclosulam PPI systems controlled common lambsquarters better than *S*-metolachlor PPI alone or fb acifluorfen plus bentazon POST or imazapic POST. Systems with diclosulam (26 g/ha) plus *S*-metolachlor PPI controlled pitted and entireleaf morningglory better than *S*-metolachlor PPI and equivalent to *S*-metolachlor PPI fb acifluorfen plus bentazon POST. *S*-metolachlor PPI was more effective than diclosulam PPI for goosegrass control. Clethodim was required for season-long control of goosegrass. S-metolachlor plus diclosulam at 17 or 26 g/ha PPI fb acifluorfen plus bentazon POST controlled common lambsquarters, pitted and entireleaf morningglory, and smooth pigweed greater than 95%. Peanut yields were similar for all treatments except *S*-metolachlor PPI alone. Peanut exhibited excellent tolerance to diclosulam PPI at 17, 26, and 35 g/ha and *S*-metolachlor plus diclosulam PPI mixtures.

Key Words: Herbicide injury, weed control, yield, acifluorfen, bentazon, imazapic.

Weed management in peanut generally requires a soil-applied dinitroanaline herbicide PPI for annual grass control followed by (fb) multiple applications of POST herbicide mixtures for broad-spectrum weed control (Bridges *et al.*, 1994; Wilcut *et al.*, 1994, 1996). Soil-applied herbicides in peanut typically used include dimethenamid, ethalfluralin, pendimethalin, and *S*-metolachlor. These herbicides control annual grasses and small-seeded broadleaf weeds such as Florida pusley (*Richardia scabra* L.), common lambsquarters (*Chenopodium album* L.), and *Amaranthus* species (Cardina and Swann, 1988; Wehtje *et al.*, 1988; Wilcut *et al.*, 1991a, 1991b). Unfortunately, these herbicides do not control larger seeded broadleaf weeds including *Ipomoea* species and prickly sida that are problematic in the Virginia-North Carolina area (Richburg *et al.*, 1996; Webster, 2001; Wilcut, 1991; Wilcut *et al.*, 1989, 1991a, 1991b, 1994). Therefore, control of these species requires POST herbicide applications. To further complicate matters for producers, there are 43 weeds of economic importance in the nine peanut growing states in the United States; seven of these are of economic importance to the Virginia-North Carolina peanut growing area (Bridges *et al.*, 1994). To control these peanut pests, growers use 22 herbicides and mechanical tactics available (Hook, 2000).

Diclosulam is a new triazolopyrimidine sulfonanilide soil-applied herbicide that is registered for broadleaf and perennial sedge weed management in peanut and soybean [*Glycine max* (L. Merr.] (Bailey *et al.*, 1999a, 1999b; Barnes *et al.*, 1998). A number of peanut varieties have exhibited excellent tolerance to diclosulam treatments (Bailey *et al.*, 2000; Main *et al.*, 2002) and diclosulam provides control of a number of troublesome annual broadleaf weeds (Bailey *et al.*, 1999a, 1999b, 2000; Main *et al.*, 2000; Price *et al.*, 2002).

Diclosulam plus ethalfluralin PPI provides broad-spectrum control of problematic weeds found in the Virginia-Carolina area (Bailey *et al.*, 1999a, 1999b). Many Virginia-North Carolina peanut growers use metolachlor PPI for annual grass control as Texas panicum (*Panicum texanum* Buckl.) is not widespread and metolachlor provides some control of yellow nutsedge (*Cyperus esculentus* L.) (Bridges *et al.*, 1994; Grichar *et al.*, 1992). Ethalfluralin and pendimethalin do not control yellow nutsedge (Wilcut *et al.*, 1994). However, metolachlor PPI is not as effective as ethalfluralin PPI for control of common lambsquarters, one of the most common broadleaf weeds in Virginia-North Carolina peanut production.

The objectives of this research were to evaluate weed control, crop response, and peanut yield with diclosulam and or *S*-metolachlor applied PPI and

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in a systems approach with registered POST herbicides.

Materials and Methods

Field experiments were conducted at the Peanut Belt Research Station located near Lewiston-Woodville, NC in 1998, the Upper Coastal Plain Research Station located near Rocky Mount, NC in 1998 and 1999, and the Tidewater Agricultural Research and Extension Center near Suffolk, VA in 1998. Soils were a Raines sandy loam (fine-loamy, siliceous, thermic, Typic Kandiudults) with 1.1% organic matter and pH 5.9 at Lewiston-Woodville, NC in 1998, a Norfolk sandy loam, (fine-loamy, siliceous, thermic, Typic Paleudults) with 1.1% organic matter and pH 5.8 at Rocky Mount, NC in 1998 and 1999, and a sandy loam with 1.5% organic matter and pH 6.1 at Suffolk. These experimental sites are representative of the major peanut producing areas of North Carolina and Virginia.

Peanut cultivars included 'NC 10 C' at Lewiston-Woodville, 'NC 7' at Rocky Mount, and 'NC-V 11' at Suffolk. Peanuts were planted 5 cm deep in smooth seedbeds at 120 to 130 kg/ha. Seeding rates were typical for these regions according to state extension recommendations. Pest management practices other than herbicide programs were based on Cooperative Extension recommendations.

Weed species evaluated included common lambsquarters (*Chenopodium album* L.), entireleaf morningglory (*Ipomoea hederacea* var. *integruiscula* Gray), goosegrass [*Eleusine indica*(L.) Gaertn.], pitted morningglory (*Ipomoea lacunosa* L.), and smooth pigweed (*Amaranthus hybridus* L.). These weeds are among the most common and troublesome weeds in North Carolina-Virginia peanut production (Webster, 2001). At the time of POST treatments, broadleaf weeds had one to six leaves with densities ranging from 1 to 35 plants per species per m^2. Plot size was four 91-cm rows that were 6.1 m in length. POST herbicides were applied 14 to 20 days after peanut emergence. These application timings are typical of commercial POST systems in North Carolina and Virginia peanut (Wilcut *et al.*, 1991a, 1991b, 1994, 1995).

Weed management systems one, two, and three received diclosulam PPI at 17, 26, or 35 g ai/ha, respectively. Systems four through six received *S*-metolachlor PPI at 1.42 kg ai/ha plus diclosulam PPI at 17, 26, or 35 g/ha, respectively. Systems seven and eight received *S*-metolachlor PPI at 1.42 kg/ha plus diclosulam PPI at 17 and 26 g/ha, respectively, fb acifluorfen at 280 g ai/ha plus bentazon at 560 g ai/ha POST. Systems nine and 10 received *S*-metolachlor PPI at 1.42 kg/ha fb acifluorfen at 280 g/ha plus bentazon at 560 g/ha POST or imazapic POST at 71 g ai/ha. Acifluorfen plus bentazon POST is the commercial standard for annual broadleaf weed control in North Carolina and Virginia peanuts while imazapic is the commercial POST standard for yellow and purple nutsedge (*Cyperus rotundus* L.) control (Bailey *et al.*, 1999a, 1999b; Richburg *et al.*, 1994, 1996; Scott *et al.*, 2002; Wilcut, 1991; Wilcut *et al.*, 1994). System 11 received *S*-metolachlor PPI at 1.42 kg/ha while system 12 was the nontreated check. A nonionic surfactant[3] at 0.25% (v/v) was applied with all POST herbicide treatments.

A randomized complete block design with three replicates of treatments was utilized at all locations. Visual estimates of crop tolerance and weed control were made early (mid-June) and late season (late August to early September). Weed control and crop tolerance were visually estimated on a scale of 0 to 100% where 0 = no control and 100% = complete death of the weeds or crop (Frans *et al.*, 1986). Because weed control at the end of the season influenced peanut yield and harvest efficiency, only late season evaluations of weed control will be presented (Wilcut *et al.*, 1994, 1995). The two center rows of each plot were harvested in mid-October using conventional harvesting equipment. Final yields were adjusted to 7% moisture.

Statistical Analyses. Data for weed control and crop injury were subjected to arcsine square root transformation before performing ANOVA. Non-transformed data are presented with statistical interpretation based on data. Data were combined over locations as there were no treatment by location interactions. For all variables, the non-treated check visual ratings were removed prior to ANOVA as no yields were obtained from these plots due to noncontrolled weeds. Means were separated using Fisher's protected LSD test at P = 0.05.

Results and Discussion

Crop injury. Only data from the 3 WAT evaluations are presented for crop injury. Crop injury from *S*-metolachlor plus diclosulam treatments or either treatment alone consisted of slight stunting that never exceeded 5% and was transitory (Table 1). This level of injury is typical from these

[3]Induce® nonionic low foam wetter/spreader adjuvant containing 90% nonionic surfactant (alkylarylpolyoxyalkane ether and isopropanol) and free fatty acids, and 10% water. Manufactured by Helena Chemical Company, Suite 500, 6075 Poplar Avenue, Memphis, TN 38137.

Table 1. Peanut injury and late-season weed control with diclosulam alone and diclosulam systems[a].

PPI herbicide (s)	POST herbicide (s)	Diclosulam rate (s)	Peanut injury	Smooth pigweed	Common lambsquarters
		g/ha	%		
Diclosulam	None	17	2 ab	100 a	96 abc
Diclosulam	None	26	4 ab	100 a	95 abc
Diclosulam	None	35	3 ab	100 a	96 abc
S-metolachlor + diclosulam	None	17	3 ab	100 a	98 ab
S-metolachlor + diclosulam	None	26	3 ab	99 a	99 ab
S-metolachlor + diclosulam	None	35	3 ab	100 a	100 a
S-metolachlor + diclosulam	Acifluorfen + bentazon	17	2 ab	100 a	99 ab
S-metolachlor + diclosulam	Acifluorfen + bentazon	26	2 ab	95 a	100 a
S-metolachlor	Acifluorfen + bentazon	None	4 b	82 b	93 bc
S-metolachlor	Imazapic	71	5 ab	100 a	90 c
S-metolachlor	None	None	4 b	73 b	70 d

[a]Means within a column followed by the same letter are not significantly different according to Fisher's Protected LSD Test at P=0.05.

herbicides in North Carolina and Virginia (Bailey *et al*., 1999a, 1999b, 2000; Price *et al*., 2001; Wilcut *et al*., 1991a, 1991b).

Smooth pigweed. Smooth pigweed was controlled 73% with *S*-metolachlor PPI and this level of control was not further improved with the addition of acifluorfen plus bentazon POST (82% control) (Table 1). However, *S*-metolachlor fb imazapic POST controlled smooth pigweed 100%. Diclosulam PPI at all rates alone controlled smooth pigweed 100%, thus control was not further improved with the addition of *S*-metolachlor PPI or POST herbicide treatments. Grichar *et al*., (1999) reported ≥95% control of Palmer amaranth (*Amaranthus palmeri* S. Wats.) with diclosulam plus ethalfluralin PPI while ethalfluralin PPI controlled 77%. They also reported 99% control of Palmer amaranth with imazapic POST.

Common lambsquarters. *S*-metolachlor PPI controlled common lambsquarter 70% and the addition of acifluorfen plus bentazon POST or imazapic POST controlled 93 and 90%, respectively (Table 1). Diclosalum PPI alone at all rates with or without metolachlor controlled at least 95% of the common lambsquarters populations. Since this level of control was so high, control with these systems was not further improved with additional herbicide inputs. Price *et al*., (2002) found that diclosulam PRE at all rates controlled common lambsquarters at least 90% in strip-tillage peanut production systems.

Pitted morningglory. Pitted morningglory was not controlled by *S*-metolachlor (2%) and control was improved to 93% with acifluorfen plus bentazon POST or imazapic POST (Table 2). Excellent control of *Ipomoea* morningglories in-

Table 2. Late-season weed control ratings and peanut yield with diclosulam alone and diclosulam systems.[a]

Herbicide (s)	POST herbicide(s)	Diclosulam rate(s) g/ha	Pitted morningglory	Entireleaf morningglory	Peanut Yield Kg/ha
Diclosulam	None	17	63 d	72 c	3780 a
Diclosulam	None	26	72 cd	78 c	3940 a
Diclosulam	None	35	91 ab	93 ab	4160 a
S-metolachlor + diclosulam	None	17	76 bcd	82 bc	4220 a
S-metolachlor + diclosulam	None	26	80 bcd	84 bc	4370 a
S-metolachlor + diclosulam	None	35	94 ab	95 ab	4140 a
S-metolachlor + diclosulam	Acifluorfen + bentazon	17	98 a	99 a	4060 a
S-metolachlor + diclosulam	Acifluorfen + bentazon	26	99 a	99 a	4010 a
S-metolachlor	Acifluorfen + bentazon	26	93 ab	85 abc	3670 a
S-metolachlor	Imazapic	71	93 ab	93 ab	3930 a
S-metolachlor	None	None	2 e	0 d	2500 b
Nontreated	None	None	0 -	0 -	1450 c

[a]Means within a column followed by the same letter are not significantly different according to Fisher's Protected LSD Test at P=0.05.

cluding pitted morningglory has been seen with imazapic POST in peanut (Bailey *et al*., 1999; Richburg *et al*., 1996; Wilcut *et al*., 1996). Acifluorfen is also widely used for pitted morningglory control in peanut (Wilcut *et al*., 1994, 1995). Diclosulam PPI controlled pitted morningglory 63 to 91% with control increasing with increased rate of application. The registered use rate of diclosulam (26 g/ha) controlled 72%. Control with diclosulam PPI or *S*-metolachlor plus diclosulam PPI was similar within a given rate of diclosulam. All diclosulam PPI treatments fb acifluorfen plus bentazon POST controlled pitted morningglory at least 98%. Bailey *et al*., (1999b) reported 90 to 99% pitted morningglory control in North Carolina with diclosulam and ethalfluralin PPI, while Grichar *et al*., (1999) reported greater than 98% control in Texas.

Goosegrass. All herbicide systems failed to control goosegrass greater than 70% (data not shown). Clethodim at 0.28 kg ai/ha plus 1.0% (v/v) crop oil concentrate was applied to all plots except the nontreated check in early July at all locations to facilitate harvest. The extensive fiberous root system of annual grasses interferes with peanut harvest and near 100% control is needed to maximize peanut yields (Wilcut *et al*., 1994). Clethodim is an effective herbicide treatment for POST control of goosegrass (Burke *et al*., 2002) and controlled goosegrass in these studies >98% (data not shown).

Entireleaf morningglory. As expected, *S*-metolachlor PPI did not control entireleaf morningglory (Table 2). The addition of either imazapic POST or acifluorfen plus bentazon POST controlled entireleaf morningglory 93 and 85%, respectively, with no difference in control. Diclosulam PPI controlled ivyleaf morningglory 72, 78, and 93% with rates of 17, 26, and 35 g/ha, respectively. A tank mixture of *S*-metolachlor plus diclosulam PPI provided similar levels of control within a given rate of diclosulam. As seen with pitted morningglory, herbicide systems using S-metolachlor plus diclosulam PPI at 17 or 26 g/ha fb acifluorfen plus bentazon POST controlled ivyleaf morningglory >98%.

Peanut yield. The value of herbicide use was apparent when peanut yield data were examined. All herbicide-treated peanut yielded 1,050 to 2,920 kg/ha more than nontreated peanut (Table 2). These yield increases reflect increased weed control from herbicide systems (Tables 1 and 2). Peanut treated with *S*-metolachlor PPI yielded 2,500 kg/ha, which was less than peanut treated with diclosulam PPI or diclosulam PPI plus *S*-metolachlor PPI. Peanut treated with diclosum PPI yielded similarly and yields were not improved with additional herbicide inputs. These data show that S-metolachlor plus diclosulam PPI controlled common lambsquarters, entireleaf morningglory, pitted morningglory, and smooth pigweed better than either herbicide applied alone. At the registered rate of 26 g/ha for diclosulam, a POST treatment of acifluorfen plus bentazon was required to control entireleaf and pitted morningglory ≥98%.

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