Control of Weeds in Peanut (*Arachis hypogaea*) Using Flumioxazin[1]

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ABSTRACT

Flumioxazin in combination with ethalfluralin provided early-season control of eclipta, pitted morningglory, and Texas panicum. Metolachlor plus flumioxazin failed to adequately control pitted morningglory (less than 80%), while flumioxazin did not control yellow nutsedge. Eclipta control with flumioxazin plus dimethenamid, imazethapyr, or metolachlor combinations were at least 99%. When flumioxazin was used in combination with dimethenamid, imazethapyr, or metolachlor, late-season yellow nutsedge control was greater than 70%. Late-season eclipta control was greater than 80% with flumioxazin alone, dimethenamid plus flumioxazin applied preemergence (PRE), ethalfluralin applied preplant incorporated (PPI) followed by (fb) flumioxazin at 0.07 kg/ha applied PRE, imazethapyr plus flumioxazin at 0.09 kg/ha applied PRE, metolachlor plus flumioxazin combinations applied PRE, or ethalfluralin applied PPI fb imazapic applied postemergence (POST). Late-season pitted morningglory control was less than 65% for all herbicide programs. Flumioxazin alone controlled no greater than 25% pitted morningglory, while ethalfluralin plus flumioxazin combinations controlled less than 48%. Late-season, flumioxazin alone controlled less than 70% Texas panicum, while ethalfluralin alone provided 84% control. All ethalfluralin plus flumioxazin combinations controlled 70 to 83% Texas panicum, while imazethapyr or metolachlor plus flumioxazin combinations controlled less than 70%. Yellow nutsedge control was greater than 70% with imazethapyr or metolachlor plus flumioxazin combinations.

Key Words: Eclipta, efficacy, groundnut, pitted morningglory, Texas panicum, yellow nutsedge.

Weeds continue to plague many peanut growers in Texas. Weed competition not only reduces peanut yield, but can also reduce harvesting efficiency, as the peanut fruit can become entangled in the weed root system and be stripped from the vine during digging (Buchanan *et al.*, 1983). Generally, control of annual grasses and small seeded broadleaf weeds can be achieved with a preplant incorporated (PPI) application of a dinitroaniline herbicide such as trifluralin [2,6-dinitro-*N,N*-dipropyl-4-(trifluoromethyl)benzenamine], pendimethalin [*N*-(1-ethylpropyl)-3,4-dimethyl-2,6-dinitrobenzenamine], or ethalfluralin [*N*-ethyl-*N*-(2-methyl-2-propenyl)-2,6-dinitro-4-(trifluoromethyl)benzenamine]. However, some weeds such as Texas panicum (*Panicum texanum* Buckl.) escape control. This may be due to extremely high weed populations, improper soil incorporation, or an inadequate herbicide rate (Grichar and Colburn, 1996).

Dinitroaniline herbicides do not adequately control eclipta (*Eclipta prostrata* L.), pitted morningglory (*Ipomoea lacunosa* L.), or yellow nutsedge (*Cyperus esculentus* L.) (Wilcut *et al.*, 1995). Dowler (1998) ranks morningglory spp. and eclipta among the 10 most common and troublesome weeds in Texas peanut. Eclipta can be a difficult problem to control in peanut in central Texas and parts of south Texas during wet years (authors' personal observations).

The soil-applied herbicides do not generally control eclipta (Wilcut *et al.*, 1995). Excellent eclipta control has been reported from a herbicide system using pendimethalin preplant incorporated (PPI), followed by metolachlor preemergence (PRE), and followed by acifluorfen {5-[2-chloro-4-(trifluoromethyl)phenoxy]-2-nitrobenzoic acid} plus bentazon [3-(1-methyletyl)-(1*H*)-2,1,3-benzothia-diazin-4(3*H*)-one 2,2-dioxide] applied postemergence (POST) (Wilcut *et al.*, 1991 a, b). Diclosulam [*N*-(2,6-dichlorophenyl)-5-ethoxy-7-fluoro(1,2,4)triazolo-(1,5-c)pyrimidine-2-sulfonamide] has also been reported to provide excellent eclipta control (Dotray *et al.*, 1998; Bailey *et al.*, 1999 a, b). In other research, herbicide systems which included lactofen {(±)-2-ethoxy-1-methyl-2-oxoethyl 5-[2-chloro-4-(trifluoro-methyl)phenoxy]-2-nitrobenzoate} applied POST provided greater than 90% control of eclipta (Wilcut *et al.*, 1990; Jordan *et al.*, 1994; Grichar and Colburn, 1996).

Texas panicum and yellow nutsedge infest all peanut growing areas of Texas (Grichar *et al.*, 1999). Imazapic {(±)-2-[4,5-dihydro-4-methyl-4-(1-methylethyl)-5-oxo-1*H*-imidazol-2-yl]-5-methyl-3-pyridinecarbolic acid} controls yellow nutsedge better than any of the currently registered peanut herbicides including imazethapyr {2-[4,5-dihydro-4-methyl-4-(1-methylethyl)-5-oxo-1*H*-imidazol-2-yl]-5-ethyl-3-pyridinecarboxylic acid} (Grichar *et al.*, 1992; Richburg *et al.*, 1995; Dotray and Keeling, 1997). Imazapic POST also has a longer period of residual weed control than imazethapyr (Wilcut *et al.*, 1995). The 18-mo crop rotation restriction following imazapic or imazethapyr use on peanut limits the use of these herbicides when rotations to cotton (*Gossypium hirsutum* L.) are anticipated (Richburg *et al.*, 1994; Grichar *et al.*, 1999).

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Flumioxazin {2-[7-fluoro-4-(2-propynl)-2*H*-1,4-benzoxazine-3-one-6-yl]-4,5,6,7-tetrahydro-2*H*-isoindole-1,3-dione} is a N-phenyl phthalimide herbicide which inhibits protoporphyrinogen oxidase (Yoshida *et al.*, 1991). In Texas, flumioxazin alone provided inconsistent control of annual grasses, while the addition of pendimethalin or trifluralin to flumioxazin improved control (Grichar and Colburn, 1996). Ivyleaf morningglory [*Ipomoea hederacea* (L.) Jacq.] control was greater than 75% when flumioxazin was used alone (Grichar and Colburn, 1996). They also noted that flumioxazin caused early season peanut stunting with recovery within 4 to 6 wk.

In North Carolina, flumioxazin preemergence (PRE) controlled prickly sida (*Sida spinosa* L.), common lambsquarters (*Chenopodium album* L.), and morningglory species better than norflurazon PRE (Askew *et al.*, 1999). In Georgia, flumioxazin PRE effectively controlled morningglories, prickly sida, and Florida beggarweed [*Desmodium tortuosum* (Sw.) DC] (Wilcut and Richburg, 1994; Wilcut, 1997; Grey *et al.*, 2002). Peanut yields when using flumioxazin have been variable. Burke *et al.* (2002) reported at one location in North Carolina that any herbicide treatment which included flumioxazin PRE resulted in a higher yield than did a single application of dimethenamid [2-chloro-*N*-(2,4-dimethyl-3-thienyl)-*N*-(2-methoxy-1-methylethyl) acetamide] or ethalfluralin PPI. They also reported that at Rocky Mount, NC in 1997, flumioxazin at 71 and 105 g/ha yielded 3,480 and 3,200 kg/ha, respectively. They concluded that at a quota price support of $0.67/kg of peanut, the yield reduction with flumioxazin at 105 g/ha would represent a loss of $187.60/ha plus the additional cost of the higher rate of flumioxazin. At one location in south Texas, flumioxazin plus metolachlor reduced peanut yield 58% from peanut in the nontreated check under weed-free conditions (Grichar, unpubl. data). However, other studies have reported no negative yield response when using flumioxazin (Wilcut *et al.*, 2001; Main *et al.*, 2003).

The objective of this study was to evaluate weed control with flumioxazin alone, in combination with ethalfluralin appplied PPI, ethalfluralin applied PPI fb flumioxazin applied PRE, or in combination with dimethenamid, imazethapyr, and metolachlor [2-chloro-*N*-(2-ethyl-6-methylphenyl)-*N*-(2-methoxy-1-methylethyl)acetamide] applied PRE compared to the commercial standard of ethalfluralin applied PPI fb imazapic applied POST.

Materials and Methods

Field studies were conducted during the 1997 and 1998 growing seasons at the Texas Agric. Exp. Sta. near Yoakum, TX. Soil type was a Tremona loamy fine sand (thermic Aquic Arenic Palenstalf) with less than 1% organic matter and pH of 7.2.

The experimental design was a randomized complete block with each treatment replicated four times. Plot size was two rows 7.6 m long, spaced 97 cm apart with a natural infestation of weeds. Pitted morningglory densities were greater than 20 plants/m^2, eclipta densities ranged from 8 to 10 plants/m^2, Texas panicum densities ranged from 4 to 6 plants/m^2, and yellow nutsedge densities were 8 to 12 plants/m^2.

The peanut cultivar GK-7 was planted each year at the rate of 90 kg/ha approximately 4 cm deep. Herbicide treatments included ethalfluralin alone at 0.84 kg ai/ha applied PPI, flumioxazin alone at 0.07 and 0.09 kg ai/ha applied PRE, ethalfluralin at 0.84 kg ai/ha plus flumioxazin at 0.07, 0.09, or 0.11 kg ai/ha applied PPI, ethalfluralin at 0.84 kg ai/ha applied PPI fb flumioxazin at 0.07, 0.09, or 0.11 kg ai/ha applied PRE, dimethenamid at 1.3 kg ai/ha plus flumioxazin at 0.09 kg ai/ha applied PRE, imazethapyr at 0.07 kg ai/ha plus flumioxazin at 0.07 or 0.09 kg ai/ha applied PRE, and metolachlor at 1.7 kg ai/ha plus flumioxazin at 0.07 or 0.09 kg ai/ha applied PRE. Ethalfluralin at 0.84 kg/ha fb imazapic at 0.7 kg ai/ha applied POST was included as the herbicide standard. A nontreated check was also included for comparison.

PPI applications of ethalfluralin were incorporated with a tractor-driven power tiller while PRE herbicides were applied immediately after peanuts were planted. Rainfall or irrigation was not received for 7 to 10 d after planting. Herbicides were applied with a CO_2 backpack sprayer using Teejet 11002 flat-fan nozzles (Spraying Systems Co., Wheaton, IL) which delivered a spray volume of 190 L/ha at 180 kPa. POST applications of imazapic included an organosilicone-based surfactant (Kinetic, a proprietary blend of polyalkyleneoxide modified polydimethylsilixane and nonionic surfactants; Helena Chemical Co., Memphis, TN) at 0.25% v/v. Eclipta was 1.5 to 3.0 cm tall, yellow nutsedge was 10 to 15 cm tall, pitted morningglory was 7 to 15 cm tall, and Texas panicum was 5 to 13 cm tall at POST application. Peanut yields were not determined due to difficulty in digging plots because of the high weed populations.

Weed control and peanut injury (stunting) were visually estimated approximately 4 and 14 wk after PRE application using a scale of 0 (no weed control or injury) to 100 (complete weed control or peanut death). All weed control data was subjected to ANOVA. Weed control data were analyzed as percentages and arcsine square root transformations. The actual percentages are reported because the transformed analyses were not different from the nontransformed analyses. Means were compared with the appropriate Fisher's protected LSD test at the 5% level of probability.

Results and Discussion

There were no significant year × treatment interactions; therefore, all weed control data were combined between years. Because peanut injury was inconsistent and less than 5% for all herbicide systems when rated 4 wk after application, stunting was not included in the analysis.

Eclipta Control. Ethalfluralin alone controlled 68% eclipta, while all flumioxazin treatments controlled at least 88% eclipta when rated 4 wk after treatment (WAT) (Table 1). Flumioxazin alone controlled at least 99% eclipta which was as good as all dimethenamid, ethalfluralin, imazethapyr, and metolachlor plus flumioxazin combinations. Only ethalfluralin applied PPI fb flumioxazin at 0.11 kg/ha applied PRE controlled less than 90%. Ethalfluralin fb imazapic applied POST controlled 94% eclipta. When rated 14 WAT, ethalfluralin alone provided 40% eclipta control, while flumioxazin alone at 0.07 and 0.09 kg/ha controlled 81 and 85%, respectively (Table 2). Ethalfluralin plus flumioxazin combinations controlled 55 to 88% eclipta. Adding dimethenamid, imazethapyr, or metolachlor to flumioxazin did not improve eclipta control over flumioxazin alone. Ethalfluralin fb imazapic controlled 86% eclipta. In earlier work, Grichar and Colburn (1996) reported excellent early-season control of eclipta with flumioxazin alone or in combination with metolachlor. They reported that late season eclipta control with flumioxazin alone was rate-dependent, while metolachlor plus flumioxazin controlled 65 to 70%.

Pitted Morningglory Control. At 4 WAT, all herbicide systems containing flumioxazin plus ethalfluralin, dimethenamid, or imazethapyr—with the exception of ethalfluralin at 0.84 kg/ha plus flumioxazin at 0.09 kg/ha applied PPI—controlled pitted morningglory at least 80%. Ethalfluralin alone, flumioxazin alone, or metolachlor plus flumioxazin provided less than 80% control (Table 1). Grichar and Colburn (1996) reported that flumioxazin alone applied PPI or PRE at 0.07 kg/ha controlled 9 to 17% less pitted morningglory than pendimethalin. They also reported that flumioxazin at 0.1 kg/ha provided greater than 95% early-season pitted morningglory control.

At the 14 WAT rating, none of the herbicide systems including ethalfluralin fb imazapic provided greater than 70% pitted morningglory control (Table 2). Ethalfluralin or flumioxazin alone controlled less than 45% pitted morningglory. When ethalfluralin was applied in combination with flumioxazin, control ranged from 30 to 48%. Dimethenamid, imazethapyr, or metolachlor in combination with flumioxazin failed to improve pitted morningglory control over flumioxazin alone. The standard of ethalfluralin applied PPI fb imazapic applied POST controlled pitted morningglory 65%.

Askew *et al.* (1999) reported no differential response with flumioxazin among entireleaf (*Ipomoea hederacea* var. *integriusculd* Gray), ivyleaf, or pitted morningglory. However, Scott *et al.* (2001) reported 85% entireleaf morningglory control, but only 63% ivyleaf morningglory control, with flumioxazin at 0.04 kg/ha.

Texas Panicum Control. Ethalfluralin and flumioxazin alone controlled at least 94% Texas panicum when rated 4 WAT (Table 1). All flumioxazin herbicide combinations controlled greater than 90% Texas panicum.

Table 1. Early-season eclipta, pitted morningglory, Texas panicum, and yellow nutsedge control with flumioxazin herbicide programs.[a]

			Control 4 WAT			
Herbicide	Rate	Application timing	Eclipta	Pitted morningglory	Texas panicum	Yellow nutsedge
	kg/ha		%			
Check	–	–	0	0	0	0
Ethalfluralin	0.84	PPI	68	76	100	0
Flumioxazin	0.07	PRE	99	62	95	39
Flumioxazin	0.09	PRE	100	73	94	20
Dimethenamid + flumioxazin	1.3 +0.09	PRE	100	91	98	84
Ethalfluralin + flumioxazin	0.84+0.07	PPI	98	91	97	50
Ethalfluralin + flumioxazin	0.84+0.09	PPI	97	64	97	44
Ethalfluralin + flumioxazin	0.84+0.11	PPI	–	89	98	35
Ethalfluralin/flumioxazin	0.84 / 0.07	PPI/PRE	100	91	99	40
Ethalfluralin/flumioxazin	0.84 / 0.09	PPI/PRE	100	93	98	44
Ethalfluralin/flumioxazin	0.84 / 0.11	PPI/PRE	88	86	98	–
Ethalfluralin/imazapic	0.84 / 0.07	PPI/POST	94	88	100	64
Imazethapyr + flumioxazin	0.07+0.07	PRE	99	86	83	66
Imazethapyr + flumioxazin	0.07+0.09	PRE	100	82	96	77
Metolachlor + flumioxazin	1.7 +0.07	PRE	100	76	99	77
Metolachlor + flumioxazin	1.7 +0.11	PRE	100	68	92	78
LSD 0.05			18	8	5	9

[a]Abbreviations: PPI = preplant incorporated; PRE = preemergence; POST = postemergence; WAT = weeks after treatment.

Table 2. Late-season eclipta, pitted morningglory, Texas panicum, and yellow nutsedge control with flumioxazin herbicide programs.[a]

Herbicide	Rate	Application timing	Control 14 WAT			
			Eclipta	Pitted morningglory	Texas panicum	Yellow nutsedge
	kg/ha		%			
Check	–	–	0	0	0	0
Ethalfluralin	0.84	PPI	40	42	84	0
Flumioxazin	0.07	PRE	81	25	56	20
Flumioxazin	0.09	PRE	85	22	69	23
Dimethenamid + flumioxazin	1.3 +0.09	PRE	90	42	61	75
Ethalfluralin + flumioxazin	0.84+0.07	PPI	58	48	73	19
Ethalfluralin + flumioxazin	0.84+0.09	PPI	71	34	72	7
Ethalfluralin + flumioxazin	0.84+0.11	PPI	–	30	70	13
Ethalfluralin/flumioxazin	0.84 / 0.07	PPI/PRE	88	40	77	17
Ethalfluralin/flumioxazin	0.84 / 0.09	PPI/PRE	73	42	76	15
Ethalfluralin/flumioxazin	0.84 / 0.11	PPI/PRE	55	42	83	–
Ethalfluralin/imazapic	0.84 / 0.07	PPI/POST	86	65	74	69
Imazethapyr + flumioxazin	0.07+0.07	PRE	53	55	54	81
Imazethapyr + flumioxazin	0.07+0.09	PRE	88	46	61	77
Metolachlor + flumioxazin	1.7 +0.07	PRE	89	33	69	71
Metolachlor + flumioxazin	1.7 +0.11	PRE	85	28	61	75
LSD 0.05			15	11	17	17

[a]Abbreviations: PPI = preplant incorporated; PRE = preemergence; POST = postemergence; WAT = weeks after treatment.

The exception was imazethapyr at 0.07 kg/ha plus flumioxazin at 0.07 kg/ha applied PRE, which controlled 83%.

At 14 WAT, ethalfluralin alone controlled 84% Texas panicum, while flumioxazin alone at 0.07 and 0.09 kg/ha provided 56 and 69% control, respectively (Table 2). Ethalfluralin is a dinitroaniline herbicide and this group of herbicides is the only soil-applied herbicides registered for use in peanut which consistently provide season-long control of Texas panicum (Wilcut *et al.*, 1987). When ethalfluralin was used in combination with flumioxazin, Texas panicum control was 70 to 83%, while ethalfluralin fb imazapic POST control was 74%. Dimethenamid, imazethapyr, or metolachlor in combination with flumioxazin controlled less than 70% Texas panicum (Table 2). Grichar and Colburn (1996) reported that under nonirrigated conditions, flumioxazin alone applied PPI at 0.1 kg/ha controlled greater than 80% Texas panicum for up to 4 wk after treatment, but control was 40% less than pendimethalin 8 wk after treatment.

Yellow Nutsedge Control. When rated 4 WAT, ethalfluralin or flumioxazin alone or in combination failed to control yellow nutsedge (Table 1). The dinitroaniline herbicides do not control yellow nutsedge (Wilcut *et al.*, 1995), and flumioxazin has failed to control yellow nutsedge in other studies (Wilcut, 1997; Askew *et al.*, 1999; Grey, *et al.* 2002). When dimethenamid was used in combination with flumioxazin, yellow nutsedge was controlled 84%, while imazethapyr or metolachlor in combination with flumioxazin controlled 66 to 78% yellow nutsedge. Ethalfluralin fb imazapic applied POST controlled yellow nutsedge 64%. Other research has shown excellent yellow nutsedge control with imazapic (Richburg *et al.*, 1994, 1995; Wilcut *et al.*, 1995).

At the 14 WAT rating, ethalfluralin or flumioxazin alone or in combination controlled less than 25% yellow nutsedge (Table 2). Dimethenamid, imazethapyr, or metolachlor in combination with flumioxazin controlled 71 to 81% yellow nutsedge, while ethalfluralin fb imazapic controlled 69%. This level of yellow nutsedge control is consistent with other research (Grichar, 1992; Grichar *et al.*, 1996, 2000). Grey *et al.* (2002) also determined that flumioxazin in combination with metolachlor inproved yellow nutsedge control over flumioxazin alone. Grichar *et al.* (2000) reported that metolachlor was more effective than dimethenamid for yellow nutsedge control. McLean *et al.* (1996) reported in greenhouse studies that dimethenamid at 1.7 kg/ha was as efficacious on yellow nutsedge as metolachlor at 2.2 kg/ha. In field studies, Grichar *et al.* (1996) reported dimethenamid at 0.8 and 1.4 kg/ha provided early-season nutsedge control comparable to metolachlor at 1.7 kg/ha under heavy yellow nutsedge pressure. However, when rated late-season, metolachlor controlled 68% yellow nutsedge, while dimethenamid controlled less than 55% yellow nutsedge regardless of rate.

Lack of season-long pitted morningglory, Texas panicum, and yellow nutsedge control with flumioxazin suggested the need for additional herbicides when these species are present. In this study, the addition of dimethenamid, imazethapyr, or metolachlor seemed to complement flumioxazin by controlling yellow nutsedge. The addition of ethalfluralin to flumioxazin improved Texas panicum control over ethalfluralin alone. POST applications of 2,4-DB or acifluorfen may be necessary to control pitted morningglory, although pitted morningglory is more tolerant to 2,4-DB and more readily controlled by acifluorfen (Barker *et al.*, 1984).

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