Interaction of Flumioxazin with Dimethenamid or Metolachlor in Peanut (*Arachis hypogaea* L.)[1]

W.J. Grichar*, B.A. Besler, P.A. Dotray, W.C. Johnson, III, and E.P. Prostko[2]

ABSTRACT

Field studies were conducted in various peanut growing regions of Texas and Georgia to study peanut response to flumioxazin alone or in combination with dimethenamid or metolachlor. In south Texas during 1997, flumioxazin plus metolachlor resulted in greater than 45% peanut stunt, while flumioxazin plus dimethenamid caused ≤ 20% peanut stunt. This stunting was attributed to cool, wet growing conditions. Peanut yields in flumioxazin plus metolachlor-treated plots were reduced 58% from peanut in the non-treated check. In 1999 and 2000, flumioxazin plus dimethenamid or metolachlor resulted in 15% or greater peanut stunt, but stunting was not constant across weather conditions or locations. In west Texas and Georgia no peanut stunting with flumioxazin was noted. At the Levelland, TX location, flumioxazin at 0.07 kg/ha plus metolachlor at 1.1 kg/ha reduced peanut yield 32% when compared with the non-treated check; while at the Pearsall, TX location, metolachlor or dimethenamid at 1.1 kg/ha, flumioxazin at 0.07 kg/ha plus dimethenamid at 1.5 kg/ha, and flumioxazin at 0.1 kg/ha plus dimethenamid at 1.1 kg/ha reduced peanut yield 24 to 48% when compared with the non-treated check. No yield reduction was noted in Georgia.

Key Words: Dual, Frontier, peanut stunting, Valor, yield.

Flumioxazin is a *N*-phenyl phthalamide soil-applied herbicide that received a federal label for use in peanut in 2001. Flumioxazin inhibits the enzyme protoporphyrinogen oxidase (Yoshida *et al.*, 1991; Anderson *et al.*, 1994; Hatzios, 1998). In Georgia, flumioxazin applied preemergence (PRE) was shown to control morningglory species (*Ipomoea* spp.), prickly sida (*Sida spinosa* L.), and Florida beggarweed [*Desmodium tortuosum* (Sw.) DC] (Wilcut, 1997). In Texas, pitted morningglory (*I. lacunosa* L.) and ivyleaf morningglory [*I. hederacea* L. (Jacq.)] were controlled greater than 75% with flumioxazin PRE (Grichar and Colburn, 1996).

Lack of yellow nutsedge (*Cyperus esculentus* L.) control with flumioxazin in other studies (Eastin *et al.*, 1993; Grichar and Colburn, 1996; Wilcut, 1997) suggest the need for a chloroacetamide herbicide when this weed is present. Askew *et al.* (1999) reported that metolachlor PRE complemented a flumioxazin-based program by controlling goosegrass [*Eleusine indica* (L.) Gaertn.] and yellow nutsedge. Scott *et al.* (2001) reported that metolachlor alone applied preplant incorporated (PPI) or metolachlor followed by (fb) flumioxazin PRE controlled at least 86% yellow nutsedge.

The use of flumioxazin in peanut has resulted in plant injury. Grichar and Colburn (1996) reported that using a dinitroaniline herbicide in a system with flumioxazin PRE fb imazethapyr or lactofen applied postemergence (POST) increased the amount of peanut stunting over pendimethalin or flumioxazin alone. For this study, metolachlor plus flumioxazin PRE fb lactofen POST resulted in greater than 10% peanut stunt when rated 6 wk after application (WAP).

In North Carolina, Askew *et al.* (1999) reported that flumioxazin at 0.07 and 0.11 kg/ha injured peanut 45 and 62%, respectively, when rated 2 WAP. Peanut stunting of greater than 60% was followed by as much as 35% discoloration, which was characterized as necrotic spots on foliage. These symptoms were consistent with other studies (Yoshida *et al.*, 1991). Askew *et al.* (1999) speculated that injury was caused by cold, wet conditions during 2 wk after PRE application. Flumioxazin enters plants mainly by shoot and root uptake, and plant injury can be avoided via rapid metabolism (Yoshida *et al.*, 1991; Anderson *et al.*, 1994). Wet, cool conditions could have increased flumioxazin uptake and/or slowed metabolism (Yoshita *et al.*, 1991). Scott *et al.* (2001) in North Carolina reported that flumioxazin treated peanuts were injured 10% when rated 3 WAP. However, injury was transient and was not apparent 6 WAP.

Chloroacetamide herbicides have also been observed to cause peanut injury in the southeastern U.S., Virginia, and Texas (Cardina and Swan, 1988; Wehtje *et al.*, 1988; Grichar *et al.*, 1996). Combinations of factors, such as herbicide rate, moisture conditions at planting, soil organic matter, and pH may affect peanut injury by chloroacetamide herbicides (Cardina and Swann, 1988; Wehtje *et al.*, 1988; Osborne *et al.*, 1995; Mueller *et al.*, 1999). Cardina and Swann (1988) reported that metolachlor often delayed peanut emergence and reduced peanut growth when irrigation followed planting. However, yield loss was observed only when metolachlor was applied at a 3× rate.

[1]This research was supported by grants from the Texas Peanut Producers Board and Valent USA.

[2]Res. Scien. (current address: Agric. Res. Sta., 3507 Hwy. 59 E., Beeville, TX 78102-9410) and Res. Assoc. (current address: Crop Docs, Inc., 521 A West Main St., Brownfield, TX 79316), Texas Agric. Exp. Sta., Yoakum, TX 77995; Assoc. Prof., Texas Agric. Exp. Sta., Lubbock, TX 79403; Res. Agron., USDA-ARS, Tifton, GA 31793-0748; and Asst. Prof., Univ. of Georgia, Tifton, GA 31793-1209, respectively.

*Corresponding author (email: w-grichar@tamu.edu).

Dimethenamid and metolachlor have been evaluated under different field moisture conditions for soybean (*Glycine max* L.) cultivar tolerance (Osborne *et al.*, 1992, 1995). Under optimum soil moisture conditions, soybean was tolerant to dimethenamid at 1.0 kg/ha and metolachlor at 1.7 kg/ha. However, when the rate of dimethenamid or metolachlor was increased to 3.0 kg/ha and 5.0 kg/ha, respectively, soybean was susceptible to injury (Osborne *et al.*, 1992, 1995). Osborne *et al.* (1992) concluded that dimethenamid was more injurious than metolachlor to soybean when high rates of both herbicides were applied. In contrast, dimethenamid was less injurious to peanut than metolachlor in studies conducted in the Southeast (Anon., 1992; Baughman and Ratliff, 1995). In Texas, slightly greater peanut stunting was observed with metolachlor than dimethenamid (Grichar *et al.*, 2000).

Flumioxazin in combination with dimethenamid or metolachlor can control a wide range of weeds in peanut (authors' personal observations). However, concerns have been expressed about potential peanut injury with this herbicide program, particularly under different growing conditions. Therefore, this study was initiated to compare flumioxazin alone and in combination with dimethenamid and metolachlor for peanut response and yield. The research was conducted in Texas and Georgia to representing two diverse peanut growing areas.

Materials and Methods

Field studies were conducted in 1997, 1999, and 2000 in two different peanut growing areas of Texas and at one location in Georgia. Soil characteristics, planting information, and weather data are presented in Table 1. Two locations at the Texas Agric. Exp. Sta. near Yoakum were selected in 1997 and 1999 and will be designated as Location 1 for the earlier planting date and Location 2 for the later planting date at each location.

At Yoakum and Pearsall, herbicides were applied with a small plot, two-row, compressed-air bicycle sprayer, equipped with three SS-11002 flat-fan nozzles (Spraying Systems, Co., Wheaton, IL). Nozzles were spaced 46 cm apart and operated to deliver a spray volume of 140 L/ha at 160 kPa. At Levelland, TX and Attapulgus, GA, a tractor-mounted CO_2 sprayer with Teejet 80015 flat fan nozzles spaced 46 cm apart was used to deliver 187 L/ha at 73 kPa. PRE treatments were applied within 30 h of peanut planting (Table 1). When required, approximately 25 mm of irrigation was applied within 48 h of peanut planting to simulate heavy rainfall and thus increase the potential for phytotoxicity.

The experimental design for all studies was a randomized complete block with three or four replications. In the 1999 and 2000 studies, treatments consisted of two flumioxazin rates (0.07 and 0.1 kg ai/ha), two rates

Table 1. Schedule of events and environmental variables at each test location.

	1997		1999				2000	
	Yoakum		Yoakum					
Parameter[a]	Location 1	Location 2	Location 1	Location 2	Attapulgus	Levelland	Yoakum	Pearsall
Planting date	8 May	16 June	17 April	31 May	20 May	11 May	17 April	31 May
Cultivar	GK-7	GK-7	GK-7	GK-7	GG	AT 120	GK-7	AT-108
Air temperature at application (C)	21.7	27.2	23.9	23.3	32.7	21.1	23.3	23.3
Low temperature for 7 d (C)	12.8	18.9	2.2	21.1	15.7	8.3	10.0	17.7
High temperature for 7 d (C)	30.6	34.4	30.0	33.9	33.5	35.6	34.4	33.9
Rainfall/irrigation for 7 d (mm)	73.9	90.7	25.4	25.4	14.7	6.35	25.4	20.3
Soil type	lf sand	fl sand	sand	sand	l sand	fs loam	sand	s loam
sand (%)	80	85	94	94	73	73	96	78
silt (%)	5	5	4	4	11	10	2	10
clay (%)	15	10	2	2	16	17	2	12
CEC	3.0	3.0	2.6	2.6	–	8.0	2.0	6.5
pH	7.0	7.0	6.8	6.8	5.8	8.0	7.4	7.3
Organic matter (%)	0.4	0.2	0.4	0.4	1.1	0.3	0.4	1.0
PRE application	9 May	16 June	17 May	31 May	20 May	11 May	17 May	31 May

[a]Abbreviations: GG = Georgia Green, lf = loamy fine, fl = fine loamy, l = loamy, fs = fine sandy, s = sandy, PRE = preemergence.

of dimethenamid or metolachlor (1.1 or 1.5 kg ai/ha), or all possible combinations of flumioxazin plus metolachlor or dimethenamid. Diclosulam was applied alone at 0.02 kg/ha as a standard and a non-treated check was used for comparisons. In 1997, treatments consisted of flumioxazin PRE alone at 0.1 kg ai/ha, or flumioxazin at 0.1 kg/ha in combination with dimethenamid at 1.3 kg ai/ha or metolachlor at 1.7 kg ai/ha. A non-treated check was also included for comparison.

All test locations were infested with low populations of annual grasses, broadleaf weeds, and nutsedge species. Pendimethalin at 0.8 kg ai/ha was applied and incorporated over the test area at each location to control annual grasses and small-seeded broadleaf weeds.

Clethodim at 0.18 kg ai/ha applied postemergence (POST) was used to control escaped Texas panicum (*Panicum texanum* Buckl.) and southern crabgrass [*Digitaria ciliaris* (Rets.) Koel.]. Pigweed and morning-glory species escapes were controlled with 2,4-DB, at 0.22 kg ai/ha applied POST while bentazon at 1.1 kg ai/ha applied POST was used to control yellow nutsedge. All plots in all studies, including the non-treated check, were maintained weed-free with these herbicides.

Peanut stunt was visually rated on a scale of 0 (no plant stunt) to 100% (plant death). Stunting was rated 4 and 9 wk after PRE treatment (WAT) in the 1997 study and 6 to 8 WAT in the 1999 to 2000 studies. Peanut stunting was based on stunting as compared to the non-treated check (here referred to as check).

Peanut yields were determined by digging the pods, air-drying in the field for 4 to 6 d, and harvesting individual plots with a combine. Peanuts were then dried to approximately 10% moisture and weights were recorded after soil and trash were removed from samples.

Plant stunting data was transformed to the arcsine square root to stabilize variance. This transformation did not change data interpretation, so nontransformed data are presented in this paper. Means for appropriate main effects and interactions were separated using Fisher's protected LSD at P = 0.05.

Results and Discussion

1997 Study

Location 1. This location received almost 74 mm of rainfall within 7 d of planting with a low temperature of under 13 C and a high temperature of over 30 C (Table 1). Flumioxazin PRE resulted in 9% stunting, flumioxazin in combination with dimethenamid caused 20% stunting, and flumioxazin in combination with metolachlor resulted in greater than 65% stunting at 4 WAT (Table 2).

At 9 WAT, flumioxazin plus dimethenamid caused 16% peanut stunting, while flumioxazin plus metolachlor resulted in greater than 45% stunting (Table 2). Peanut yields reflect the stunting noted in visual ratings where flumioxazin plus metolachlor reduced peanut yield by 48% when compared with flumioxazin alone (Table 2).

Location 2. This location received more rainfall than Location 1 but temperatures were much higher for the 7 d after application time period (Table 1). No visible stunting was noted with flumioxazin alone or in combination with metolachlor when rated 4 or 9 WAT (Table 2). Flumioxazin in combination with dimethenamid caused 3% or less peanut stunting at either rating date. No significant difference in peanut yields was noted among herbicide treatments.

1999 and 2000 Studies

Peanut Injury. In 1999 at Location 1, peanut stunting with flumioxazin ranged from 5 to 9%, while dimethenamid or metolachlor alone resulted in ≤ 3% stunting

Table 2. Peanut stunting and peanut yield response to flumioxazin alone or in combination with metolachlor or dimethanmid under weed free conditions, 1997.

Treatment	Rate	Application timing[a]	Stunting 4 WAT Location 1[b]	Stunting 4 WAT Location 2	Stunting 9 WAT Location 1	Stunting 9 WAT Location 2	Yield Location 1[b]	Yield Location 2
	kg ai/ ha		%				kg/ha	
Flumioxazin	0.1	PRE	9	0	0	0	3100	2580
Flumioxazin + metolachlor	0.1 1.7	PRE	68	0	49	0	1500	3570
Flumioxazin + dimethenamid	0.1 1.3	PRE	20	1	16	3	2230	3320
Check	–	–	0	0	0	0	2580	2260
LSD (0.05)	12	1	19	2	1120	NS		

[a]PRE = preemergence.

[b]Both locations at Yoakum, TX.

(Table 3). Flumioxazin at 0.1 kg/ha plus metolachlor or dimethenamid at 1.1 or 1.5 kg/ha, respectively, resulted in at least 18% peanut stunt.

The daily low temperature for the 7 d after application was < 3 C which represents below normal temperatures in south central Texas for that time of year (Table 1). No other weather extremes were noted for either Yoakum location.

At Location 2, peanut stunting was observed with metolachlor alone at 1.1 kg/ha and all flumioxazin plus metolachlor combinations. Dimethenamid alone caused almost no peanut stunting, while flumioxazin plus dimethenamid resulted in 6% or less peanut stunt. Grichar *et al.* (2001) reported variable peanut stunt with metolachlor PRE, where stunting ranged from 5% or less with metolachlor at 1.7 kg/ha to greater than 20% with metolachlor at 4.5 kg/ha.

At the west Texas location near Levelland, diclosulam caused 13% peanut stunting (Table 3). Karnei *et al.* (2002) reported 17 to 30% peanut stunting 14 d after planting following diclosulam at 0.024 lb ai/A applied PPI and PRE. However, stunting was not observed at the time of harvest. No peanut stunting was noted with any herbicide treatment at Attapulgus (data not shown).

In 2000 at Yoakum, flumioxazin alone at 0.1 kg/ha, flumioxazin at 0.1 kg/ha plus metolachlor at 1.1, or flumioxazin at 0.1 kg/ha plus dimethenamid at 1.5 kg/ha resulted in at least 7% peanut stunting (Table 3). No stunting was noted at the Pearsall location (data not shown).

The low temperature for the 7 d period after herbicide application at Yoakum was 10 C, while at Pearsall it was 18 C. Both locations received ≤ 25.4 mm rainfall during the 7 d period. These factors contributed to minimal herbicide phytotoxicity on peanut in 2000. Low rainfall may have decreased flumioxazin uptake, and moderate temperatures did not slow plant metabolism of flumioxazin (Yoshida *et al.* 1991).

Peanut Yield. In 1999, although peanut stunting was visible throughout the growing season at several locations, reductions in peanut yield from the check were not noted. No differences between the check and any herbicide treatments were observed in 1999 at either Yoakum location (Table 4). At Levelland, only flumioxazin at 0.07 kg/ha plus metolachlor at 1.1 kg/ha reduced yields as compared to the check. Although diclosulam caused 10% stunting when rated 6 wk after treatment, no reduction in yield as compared to the check was recorded (Table 4). Grichar *et al.* (1999) also reported no yield reductions from diclosulam, although some early season peanut stunting was noted.

At Attapulgus, none of the herbicide treatments produced lower yields than the check. However, flumioxazin at 0.1 kg/ha, flumioxazin at 0.07 kg/ha plus metolachlor at 1.5 kg/ha or dimethenamid at 1.1 kg/ha, and diclosulam resulted in increased yields of 16 to 22% over the check (Table 4).

Table 3. Peanut stunting at each test location.

Treatment	Rate	1999 (6 WAT[b]) Location 1[a]	1999 (6 WAT[b]) Location 2	1999 (6 WAT[b]) Levelland	2000 Yoakum
	kg ai/ha	%			
Flumioxazin	0.07	5	3	0	4
Flumioxazin	0.1	9	5	0	8
Metolachlor	1.1	3	11	0	0
Metolachlor	1.5	0	6	0	0
Dimethenamid	1.1	3	0	0	0
Dimethenamid	1.5	3	1	0	3
Flumioxazin + metolachlor	0.07+ 1.5	13	8	0	7
Flumioxazin + metolachlor	0.1+ 1.5	6	16	0	5
Flumioxazin + metolachlor	0.1+ 1.1	19	10	0	9
Flumioxazin + metolachlor	0.1+ 1.5	18	15	0	13
Flumioxazin + dimethenamid	0.07+ 1.1	19	6	0	0
Flumioxazin + dimethenamid	0.07+ 1.5	8	6	0	4
Flumioxazin + dimethenamid	0.1+ 1.1	19	5	0	4
Flumioxazin + dimethenamid	0.1+ 1.5	16	5	0	9
Diclosulam	0.02	13	0	13	0
Check	–	0	0	0	0
LSD (0.05)		13	6	1	7

[a]Both locations in 1999 at Yoakum, TX.
[b]WAT = weeks after treatment.

In 2000 at Yoakum, the high rates of flumioxazin or dimethenamid alone reduced peanut yield as compared to the check. At Pearsall, metolachlor alone, dimethenamid alone at 1.1 kg/ha, flumioxazin at 0.07 kg/ha plus dimethenamid at 1.5 kg/ha, and flumioxazin at 0.1 kg/ha plus dimethenamid at 1.1 kg/ha reduced yields (Table 4).

Although flumioxazin did cause significant early-season stunting in some instances, no common weather or environmental conditions could be found that would indicate a problem with peanut growth on a consistent basis. In 1997, when severe stunting (> 60%) and a reduction in yield were noted, very heavy rainfall (> 70.0 cm) occurred within 7 d of herbicide application along with below average air temperatures. Environmental conditions enhanced the peanut stunting and contributed to slow early-season growth.

Acknowledgments

Karen Jamison assisted in manuscript preparation. This research was supported by Valent USA and the Texas Peanut Producers Board.

Table 4. Peanut yield at each test location.

Treatment	Rate	1999				2000	
		Location 1[a]	Location 2	Attapulgus	Levelland	Pearsall	Yoakum
	kg ai/ha	kg/ha				kg/ha	
Flumioxazin	0.07	1780	3320	5240	4600	3580	2030
Flumioxazin	0.1	1890	2810	5490	4720	3170	1540
Metolachlor	1.1	2450	2480	–	4940	2710	2040
Metolachlor	1.5	2040	3140	4810	4740	2440	2010
Dimethenamid	1.1	2010	3200	–	4710	2170	2120
Dimethenamid	1.5	2160	2910	5270	4770	3960	1420
Flumioxazin + metolachlor	0.07+ 1.1	2210	2760	–	3300	3990	1890
Flumioxazin + metolachlor	0.07+ 1.5	3090	2190	5350	4670	3910	1990
Flumioxazin + metolachlor	0.1+ 1.1	2250	2420	–	4500	3960	1960
Flumioxazin + metolachlor	0.1+ 1.5	2530	2170	5030	4450	4450	2220
Flumioxazin + dimethenamid	0.07+ 1.1	2450	2800	5400	4140	3320	2400
Flumioxazin + dimethenamid	0.07+ 1.5	2460	2360	–	5330	1850	1600
Flumioxazin + dimethenamid	0.1+ 1.1	2680	2760	–	4630	2710	2120
Flumioxazin + dimethenamid	0.1+ 1.5	2020	2760	5190	4700	3530	2050
Diclosulam	0.02	2630	4070	5620	3590	3260	1610
Check		2430	3030	4620	4880	3580	2400
LSD (0.05)		1100	1080	660	1310	660	900

[a]Both locations at Yoakum, TX.

Literature Cited

Anderson, R.J., A.E. Norris, and F.D. Hess. 1994. Synthetic organic chemicals that act through the prophyrin pathway, pp. 18-33. *In* S.O. Duke and C.A. Rebeiz (eds.) Porphyric Pesticides: Chemistry, Toxicology, and Pharmaceutical Applications. ACS Symposium Series 559. Washington, DC. Amer. Chem. Soc.

Anon. 1992. Dimethenamid Experimental Herbicide: A Technical Overview. Sandoz Agra, Inc., Des Plaines, IL.

Askew, S.D., J.W. Wilcut, and J.R. Cranmer. 1999. Weed management in peanut (*Arachis hypogaea*) with flumioxazin preemergence. Weed Technol. 13:594-598.

Baughman, T., and R.L. Ratliff. 1995. Frontier, a new herbicide for weed management systems in peanut. Proc. Amer. Peanut Res. Educ. Soc. 27:64 (abstr.).

Cardina, J., and C.W. Swann. 1988. Metolachlor effects on peanut growth and development. Peanut Sci. 15:57-60.

Eastin, E.F., J.W. Wilcut, J.S. Richburg, III, and T.V. Hicks. 1993. V-53482 and Zorial systems for weed control in Georgia peanut. Proc. Amer. Peanut Res. Educ. Soc. 25:84 (abstr.).

Grichar, W.J., and A.E. Colburn. 1996. Flumioxazin for weed control in Texas peanuts (*Arachis hypogaea* L.). Peanut Sci. 23:30-36.

Grichar, W.J., A.E. Colburn, and P.A. Baughman. 1996. Yellow nutsedge (*Cyperus esculentus*) control in peanut (*Arachis hypogaea*) as influenced by method of metolachlor application. Weed Technol. 10:278-281.

Grichar, W.J., P.A. Dotray, and D.C. Sestak. 1999. Diclosulam for weed control in Texas peanut. Peanut Sci. 26:23-28.

Grichar, W.J., R.G. Lemon, K.D. Brewer, and B.W. Minton. 2001. *S*-metolachlor compared with metolachlor on yellow nutsedge (*Cyperus esculentus*) and peanut (*Arachis hypogaea*). Weed Technol. 15:107-111.

Grichar, W.J., R.G. Lemon, D.C. Sestak, and K.D. Brewer. 2000. Comparison of metolachlor and dimethenamid for yellow nutsedge (*Cyperus esculentus* L.) control and peanut (*Arachis hypogaea* L.) injury. Peanut Sci. 27:26-30.

Hatzios, K.K. (ed.). 1998. Herbicide Handbook Supplement to the 7th ed. Weed Sci. Soc. Amer. Champaign, IL. 104 p.

Karnei, J.K., P.A. Dotray, J.W. Keeling, and T.A. Baughman. 2002. Weed control and peanut response to diclosulam. Proc. South. Weed Sci. Soc. 55:32 (abstr.).

Mueller, T.C., D.R. Shaw, and W.W. Witt. 1999. Relative dissipation of acetochlor, alachlor, metolachlor, and SAN 582 from three surface soils. Weed Technol. 13:341-346.

Osborne, B.T., D.R. Shaw, and R.L. Ratliff. 1995. Response of selected soybean (*Glycine max*) cultivars to dimethenamid and metolachlor in hydropnic conditions. Weed Technol. 9:178-181.

Osborne, B.T., D.R. Shaw, R.L. Ratliff, and G.P. Ferguson. 1992. Soybean cultivar tolerance to SAN 582 and metolachlor as influenced by soil moisture. Proc. South. Weed Sci. Soc. 45:52 (abstr.).

Scott, G.H., S.D. Askew, and J.W. Wilcut. 2001. Economic evaluation of diclosulam and flumioxazin systems in peanut (*Arachis hypogaea*). Weed Technol. 15:360-364.

Wehtje, G., J.W. Wilcut, T.V. Hicks, and J. McGuire. 1988. Relative tolerance of peanuts to alachlor and metolachlor. Peanut Sci. 15:53-56.

Wilcut, J.W. 1997. Summary of flumioxazin performance in southeastern peanuts. Proc. South. Weed Sci. Soc. 50:7 (abstr.).

Yoshida, R., M. Sakaki, R. Sato, T. Haga, E. Nogano, H. Oshio, and K. Kamoshita. 1991. S-53482-a new N-phenyl phthalimide herbicide. Proc. Brighton Crop Prot. Conf., Weeds 1:69-75.