Use of Endothall in a Peanut (*Arachis hypogaea*) Herbicide Program

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ABSTRACT

Field studies were conducted in 1992 and 1993 to evaluate endothall alone and in various herbicide programs for weed control in Texas peanut production. Endothall alone controlled less Texas panicum and southern crabgrass than bentazon + paraquat. The addition of Cadre (AC 263,222) or Pursuit (imazethapyr) to endothall improved weed control and provided early season control of Texas panicum, southern crabgrass, yellow nutsedge, and pitted morningglory.

KEYWORDS: yellow nutsedge, *Cyperus esculentus*, Texas panicum, *Panicum texanum*, pitted morningglory, *Ipomoea lacunosa*, Cadre, Pursuit

Endothall has contact herbicide activity similar to paraquat and is registered for use in the U.S. in alfalfa (*Medicago sativa* L.) and clover (*Trifolium* spp.) as a desiccant, in cotton (*Gossypium hirsutum* L.) as a harvest aid, in sugar beets (*Beta vulgaris* L.) for broadleaf weed control, and in aquatic situations for control of aquatic weeds and algae (Anonymous, 1994).

Texas panicum (*Panicum texanum* Buckl.), yellow nutsedge (*Cyperus esculentus* L.), pigweed (*Amaranthus* spp.), and morningglory (*Ipomoea* spp.) can be difficult to control in southwestern peanuts (Grichar and Boswell, 1986; Grichar, 1991a; Grichar, 1991b; Grichar, 1992; Grichar et al., 1992; Grichar et al, 1994; Grichar, 1994). Paraquat (Gramoxone) alone or in combination with 2,4-DB (Butoxone) or bentazon (Basagran) are currently the standards for postemergence broadleaf weed control in southeastern peanut production (Wilcut et al., 1989; Wilcut, 1991; Wilcut et al., 1991). Not only does the bentazon plus paraquat mixtures control more broadleaf weed species than paraquat alone but the bentazon also reduces paraquat-induced foliar injury to peanut by reducing paraquat absorption into peanut foliage (Wehtje et al., 1992; Wilcut et al., 1993). However, little paraquat is used in southwestern peanuts due to the potential for early season peanut leaf burning and desiccation.

Although paraquat applied postemergence to the peanut plant injures the foliage (Brecke and Colvin, 1988; Wehtje et al., 1986; Wilcut and Swann, 1990), peanut rapidly recovers under good growing conditions and yield is unaffected. Peanut

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tolerance to paraquat is not cultivar dependent (Knauft et al., 1990; Wehtje et al., 1991) and seedling tolerance to paraquat is not influenced by seed size. Paraquat can be applied from crop emergence until 28 d after emergence (Anonymous, 1994); however, paraquat applied after this 28 d period increased the chance of significant yield reductions (Wehtje et al., 1986).

Endothall has recently been investigated for weed control in peanuts (Brecke and Colvin, 1994; Colvin and Johnson, 1992; Johnson and Colvin, 1992a, Johnson and Colvin 1992b, Johnson et al., 1994; Wehtje et al., 1991). Peanut injury in the southeast with endothall has ranged from 10% to as high as 50%, according to time of application (Colvin and Johnson, 1992; Johnson et al., 1994). The authors concluded that the level of phytotoxicity with endothall was similar to that from bentazon plus paraquat (Johnson et al., 1992a; Johnson et al., 1992b; Johnson et al., 1994).

Brecke and Colvin (1994) reported variable control of tall morningglory (*Ipomoea purpurea* (L.) Roth) with endothall but they felt that this was due to differences in size of tall morningglory at treatment. They concluded that the application of endothall must be made after the initial flush of weeds have emerged but before the largest weeds exceed 4 to 6 inches in height (Brecke and Colvin, 1994). Johnson et al. (1994) found that the mono (N,N-dimethylalkylamine) salt of endothall was more necrotic to peanut than those treated with the dipotassium salt of endothall. They reported that at rates of 0.5 to 1.0 lb ai acre $^{-1}$, the mono salt of endothall resulted in similar amount of peanut injury as the standard treatment of bentazon plus paraquat.

Endothall is a contact herbicide that produces rapid, necrotic lesions on treated plant tissue (MacDonald et al., 1993). Research indicated that endothall inhibits lipid, protein, and mRNA biosynthesis (MacDonald et al., 1993). The effects of endothall on ion leakage, chlorophyll fluorescence, and oxygen consumption are similar to those exhibited by compounds that affect respiration, suggesting that endothall causes plant death through an alteration of normal respiratory function, inhibiting the ability of the plant cells to maintain cellular integrity (MacDonald et al., 1993).

The objectives of this research were to evaluate weed control, peanut tolerance, and peanut yields from herbicide programs containing endothall with a standard commercial program.

MATERIALS AND METHODS

Field studies were conducted in Lavaca County at the Texas Agricultural Experiment Station near Yoakum, TX. The soil was a Tremona loamy fine sand (thermic Aquic Arenic Paleustalfs) with less than 1% organic matter and a pH of 7.2.

Studies were established on different irrigated fields in 1992 and 1993. Peanuts had previously been planted in each of these fields for the past 15 years. 'Florunner' peanut at 90 lb acre^{-1} was planted 11 May 1992 and 20 May 1993. No preplant incorporated (PPI) herbicide was applied to the test area. Weed populations were determined at herbicide application. The 1992 area was naturally infested with mixed populations of Texas panicum (60%) and southern crabgrass (40%) (>4 to

5 total plants ft^{-2}), pitted morningglory (*Ipomoea lacunosa* L.) (>1 plant ft^{-2}), and yellow nutsedge (>4 plants ft^{-2}). The 1993 test site was naturally infested with mixed populations of southern crabgrass (70%) and Texas panicum (30%) (>3 total plants ft^{-2}) and yellow nutsedge (>4 plants ft^{-2}).

EPOST treatments were applied 8 Jun 1992, and 10 Jun 1993 while LPOST treatments were applied 18 Jun 1992 and 24 Jun 1993. Annual grasses were 1 to 2 inches tall at early postemergence (EPOST) and 4 to 6 inches tall at late postemergence (LPOST). Pitted morningglory was 2 to 4 inches tall at EPOST and 6 to 8 inches tall at LPOST, while yellow nutsedge varied from 4 to 6 inches tall at EPOST and 8 to 10 inches tall at LPOST.

Herbicide treatments included endothall alone at 0.5, 0.75, and 1.0 lb ai $acre^{-1}$, endothall at 0.5 lb ai $acre^{-1}$ applied in combination with either AC 263,222 at 0.063 lb ai $acre^{-1}$, imazethapyr at 0.063 lb $acre^{-1}$, or 2,4-DB at 0.25 lb ai $acre^{-1}$ applied EPOST or LPOST. Bentazon at 0.5 lb ai $acre^{-1}$ + paraquat at 0.12 lb ai $acre^{-1}$, applied EPOST or LPOST were included as comparison treatments.

Herbicides were applied with a compressed-air bicycle sprayer through Teejet 11002 flat fan nozzles (Spraying Systems Co., Wheaton, IL) which delivered a spray volume of 20 gal $acre^{-1}$ at 26 psi. Imazethapyr (Pursuit) and AC 263,222 (Cadre) + endothall and bentazon + paraquat were applied with a nonionic surfactant (X-77) at 0.25% (v/v) of the spray volume.

A factorial arrangement of treatments with factors consisting of herbicide treatments and timing of application (EPOST vs LPOST) in a randomized complete block experimental design with four replications was used. Each plot consisted of two rows spaced 36 inches apart and 25 feet long. In both years, paraquat + bentazon was the standard treatment. Sprinkler irrigation was applied on a two week schedule throughout the growing season as needed.

Data collected included visual estimates of crop injury and weed control on a scale of 0% (no control or peanut injury) to 100% (complete control or death of the peanuts) relative to the untreated check, and peanut yield. Weed control and peanut injury were visually estimated early and late-season during both years.

Peanut yields were obtained by digging each plot separately, air-drying in the field for 4 to 8 days, and harvesting peanut pods from each plot with a combine. Weights were recorded after soil and foreign material were removed from the plot samples. Visible weed control data were subjected to arcsine transformation prior to analysis of variance. Untransformed data were used for presentation. Peanut yields were subjected to analysis of variance, and significant differences ($P \leq 0.05$) among means were determined with Fisher's Protected Least Significant Difference.

RESULTS AND DISCUSSION

Data analysis revealed significant year by treatment interaction, therefore data were analyzed separately for each year.

Annual grass control

In 1992, when rated two weeks after LPOST treatment (2WAT), only the EPOST application of endothall alone at 0.5 and 1.0 lb ai $acre^{-1}$, endothall + AC 263,222, or endothall + imazethapyr provided early season control of the annual grasses

(Texas panicum and southern crabgrass) equal to the standard of bentazon + paraquat (EPOST) (Table 1). Endothall alone controlled ≤70% of the annual grasses while paraquat + bentazon controlled 63 to 79%. In previous studies, it was found that Texas panicum can be controlled with paraquat or a paraquat plus bentazon mixture (Wehtje et al., 1986; Wehtje et al., 1992). However, if Texas panicum is larger than the five- to six-leaf stage, bentazon will reduce paraquat efficacy (Wehtje et al., 1992). Although application timing was not significant, a trend toward better grass control with EPOST treatments of bentazon + paraquat, endothall at 0.5 and 1.0 lb ai acre^{-1} and endothall + 2,4-DB was apparent (Table 1). No differences in control were noted for timing of application with endothall + AC 263,222 or endothall + imazethapyr combinations. However, the LPOST application of endothall + AC 263,222 resulted in better annual grass control than the LPOST endothall + imazethapyr combination.

Late season annual grass control (6 WAT) in 1992 was <70% for all herbicide treatments (Table 1). Endothall alone controlled 45 to 61% of the annual grasses while bentazon + paraquat controlled 46 to 65%. Poor grass control (<70%) was evident with endothall + AC 263,222 or endothall + imazethapyr although these herbicides (AC 263,222 and imazethapyr) do have residual activity (Richburg et al., 1994; Wixson and Shaw, 1991; Wixson and Shaw, 1992). Imazethapyr has been reported to provide less control of annual grasses than AC 263,222 (Grichar et al., 1994; Wilcut et al., 1993).

In 1993, endothall + imazethapyr, or endothall + AC 263,222 provided early season annual grass control comparable with bentazon + paraquat (Table 2). Endothall alone controlled 59 to 84% of annual grasses. The EPOST application resulted in better annual grass control with bentazon + paraquat or endothall alone at 0.75 and 1.0 lb ai acre^{-1} than the LPOST application. Earlier work by Brecke and Colvin (1994) indicated weed size was an important factor in effective control with endothall.

Annual grass control 10 WAT with EPOST and LPOST applications endothall + AC 263,222 or endothall plus imazethapyr applied EPOST was ≥78% (Table 2). Endothall at 1.0 lb ai acre^{-1} applied EPOST or LPOST was comparable to bentazon + paraquat applied EPOST, but these herbicide treatments provided <50% annual grass control.

Pitted morningglory control

Only in 1992 was the pitted morningglory population uniform enough to provide accurate assessment. Only the EPOST applications of paraquat and the 0.5 lb ai acre^{-1} rate of endothall controlled less morningglory than the LPOST application of bentazon + paraquat when rated 2 WAT (Table 1).

Morningglory control 10 WAT was less with bentazon + paraquat applied EPOST or LPOST and endothall at 0.75 lb ai acre^{-1} applied LPOST than the EPOST endothall + 2,4-DB application (Table 1). Since annual grass pressure was so great, after the initial flush of morningglory was killed, the high numbers of annual grass plants likely prevented germination and additional flushes of morningglory in plots which did not have a residual herbicide. Therefore, few differences were seen in late season morningglory control between herbicide treatments. Brecke and Colvin (1994) reported inconsistent control of tall morningglory [*Ipomoea purpurea* (L.) Roth] regardless of application timing. They concluded that the variation in control

was due to differences in weed growth. They stated that endothall must be applied after the initial flush of weeds have emerged but before the largest weeds exceed 5 inches in height.

Yellow nutsedge control

In 1992, endothall alone failed to provide effective (<50%) early season yellow nutsedge control, while bentazon + paraquat provided 90% control (Table 1). Endothall + AC 263,222 resulted in ≥89% control of yellow nutsedge while endothall + imazethapyr controlled 65 to 73% early season (Table 2). AC 263,222 has provided better control of yellow nutsedge in field experiments than currently registered herbicides in peanut (Wilcut and Richburg, 1992).

Late season yellow nutsedge control with LPOST applications of endothall + AC 263,222 or endothall + 2,4-DB was comparable with bentazon + paraquat applied LPOST. Postemergence imazethapyr applications can control yellow nutsedge (Grichar et al., 1992; Richburg et al., 1994; Wiley et al., 1991). However, imazethapyr needs to be applied when yellow nutsedge is 2 to 4 inches tall for greatest efficacy (Brecke and Colvin, 1994; Richburg et al., 1994; Wiley et al., 1991). Grichar et al. (1992) reported late season yellow nutsedge control with imazethapyr was higher with PPI applications than other applications.

In 1993, endothall control of yellow nutsedge 3 WAT alone varied from 30 to 68% and was not rate dependent (Table 2). Bentazon + paraquat applied LPOST provided 23 to 61% better nutsedge control than any of the endothall alone treatments. The addition of imazethapyr or AC 263,222 improved yellow nutsedge control over all endothall treatments except for the endothall at 0.5 lb ai $acre^{-1}$ applied EPOST. Bentazon + paraquat control was 20% less with the EPOST treatment than the LPOST treatment.

Nutsedge control 10 WAT was ≤60% with all herbicide treatments. Endothall combinations with AC 263,222 and imazethapyr provided poor control. Inconsistent yellow nutsedge control, especially later in the growing season, has been reported with imazethapyr (Grichar et al., 1992).

Peanut injury

Peanut injury was not rated at the Yoakum location in 1992 because heavy rains fell soon after EPOST application and prevented entry into the field to provide an accurate assessment. Injury (peanut burn) in 1993 with endothall was comparable with bentazon + paraquat applied EPOST (Table 1). Previous work in the Southeast indicated peanut injury from applications of paraquat alone averaged 30% and did not differ with timing of paraquat application (Wilcut and Swann, 1990). However, provided the rate of paraquat is not excessive (≤0.25 lb ai $acre^{-1}$), and the applications are restricted to early in the growing season (not later than 28 days after emergence), yield has not adversely affected (Wehtje et al., 1986).

Peanut yield

In 1992, endothall alone resulted in 13 to 36% yield reduction when compared with the EPOST bentazon + paraquat application (Table 1).

In 1993, a series of record setting cool temperatures in early to mid October

Table 1. Control of Texas panicum, morningglory, and yellow nutsedge with contact herbicides alone and in combinations, Lavaca County, TX, 1992.

Treatment	Rate	Application time†	Weed control‡ 2 WAT§ Grass	2 WAT Morningglory	2 WAT Nutsedge	6 WAT Grass	6 WAT Morningglory	6 WAT Nutsedge	Peanut yield
	lb ai acre^{-1}		%			%			lb acre^{-1}
Bentazon	0.5	EPOST	79	75	90	65	73	61	2151
+paraquat	0.12								
Bentazon	0.5	LPOST	63	90	90	46	88	88	1474
+paraquat	0.12								
Endothall	0.5	EPOST	66	75	45	45	95	70	1661
Endothall	0.5	LPOST	53	96	15	48	95	46	1880
Endothall	0.75	EPOST	43	95	35	58	95	53	1607
Endothall	0.75	LPOST	53	89	33	61	88	73	1380
Endothall	1.0	EPOST	70	93	31	45	93	48	1570
Endothall	1.0	LPOST	41	95	43	48	90	50	1516
Endothall	0.5	EPOST	82	90	93	63	89	79	1779
+AC 263,222	0.063								
Endothall	0.5	LPOST	85	98	89	65	99	86	1316
+AC 263,222	0.063								
Endothall	0.5	EPOST	74	93	73	61	90	63	1825
+imazethapyr	0.063								
Endothall	0.5	LPOST	69	100	65	60	96	70	1552
+imazethapyr	0.063								

Table 1, continued.

Treatment	Rate	Application time†	Weed control‡ 2 WAT§ Grass	Morningglory	Nutsedge	6 WAT Grass	Morningglory	Nutsedge	Peanut yield
	lb ai acre^{-1}		%						lb acre^{-1}
Endothall	0.5	EPOST	56	98	33	44	100	75	2088
+2,4-DB	0.25								
Endothall	0.5	LPOST	34	99	8	53	99	85	1797
+2,4-DB	0.25								
LSD (0.05)									
Treatment			15	9	26	15	11	24	449
Appl. time			NS	NS	NS	NS	NS	NS	NS
Treatment X Appl. time			NS	NS	NS	NS	NS	NS	NS

†Application timing: EPOST=early postemergence, LPOST=late postemergence.
‡Grass=Annual grasses, a mixed stand of 60% Texas panicum and 40% southern crabgrass; Morningglory=pitted morningglory; Nutsedge=yellow nutsedge.
§WAT=weeks after LPOST treatment.

Table 2. Control of southern crabgrass and yellow nutsedge with contact herbicides alone and in combinations, Lavaca County, TX, 1993.

Treatment	Rate	Application time[†]	Peanut injury (5 DAT)[‡]	Weed control[§] 3 WAT[¶] Grass	3 WAT Nutsedge	10 WAT Grass	10 WAT Nutsedge	Peanut yield
	lb ai acre^{-1}			%				lb acre^{-1}
Bentazon +paraquat	0.5 0.12	EPOST	33	89	71	40	28	874
Bentazon +paraquat	0.5 0.12	LPOST	11	68	91	15	50	946
Endothall	0.5	EPOST	25	70	68	5	30	723
Endothall	0.5	LPOST	26	70	45	10	10	1160
Endothall	0.75	EPOST	30	71	55	15	20	1160
Endothall	0.75	LPOST	26	59	55	25	40	803
Endothall	1.0	EPOST	38	84	30	41	23	874
Endothall	1.0	LPOST	33	70	35	40	25	651
Endothall +AC 263,222	0.5 0.063	EPOST	23	99	95	78	30	1240
Endothall +AC 263,222	0.5 0.063	LPOST	23	96	73	84	58	1312
Endothall +imazethapyr	0.5 0.063	EPOST	33	97	81	88	20	1526
Endothall +imazethapyr	0.5 0.063	LPOST	28	91	84	56	30	874
Endothall +2,4-DB	0.5 0.25	EPOST	25	83	20	40	20	560

Table 2 continued.

Treatment	Rate	Application time†	Peanut injury (5 DAT)‡	Weed control§ 3 WAT¶ Grass	3 WAT¶ Nutsedge	10 WAT Grass	10 WAT Nutsedge	Peanut yield
	lb ai acre^{-1}			%				lb acre^{-1}
Endothall	0.5	LPOST	21	75	55	10	20	1200
+2,4-DB	0.25							
LSD (0.05)								
Treatment			9	9	20	17	31	303
Appl. Time			NS	7	NS	NS	NS	NS
Treatment X Appl. Time			NS	NS	NS	NS	14	382

†Application timing: EPOST=early postemergence, LPOST=late postemergence.
‡DAT=days after treatment
§Grass=Annual grasses, a mixed stand of 70% southern crabgrass and 30% Texas panicum.
¶WAT=weeks after LPOST treatment.

resulted in delayed maturity and lower yields. Endothall + AC 263,222 applied LPOST, endothall + imazethapyr applied EPOST, and pendimethalin + imazethapyr resulted in a yield increase over the untreated check. In neither year did endothall result in a decreased yield from the untreated check.

Johnson et al. (1994) reported that peanut yields were not affected by endothall at 0.5 to 1.0 lb ai $acre^{-1}$, applied from vegetative emergence through four weeks after emergence.

CONCLUSION

This study demonstrates that early season control of annual grasses (Texas panicum and southern crabgrass), pitted morningglory, and yellow nutsedge with endothall was comparable with bentazon + paraquat. However, when endothall was tank-mixed with AC 263,222 season long control of annual grasses and pitted morningglory were possible. Early season yellow nutsedge control was excellent with endothall + AC 263,222; however, late season control was inconsistent.

Since early season peanut injury with endothall is comparable to paraquat, the use of endothall for peanut weed control will probably be limited to the southeastern U.S. where growers are comfortable with some burning of peanut leaves by paraquat.

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