Effects of Paraquat Application and Timing on Peanut (*Arachis hypogaea* L.) Growth, Yield and Grade

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ABSTRACT

Field studies were conducted to evaluate paraquat or paraquat and bentazon mixtures and timing of application on runner-type peanut yield, injury, and grade. Single applications of paraquat at 0.14 kg ha-1 reduced peanut plant growth when applied 7, 14, 21, and 28 days after peanut emergence (DAE). Multiple applications of paraquat applied at peanut emergence (Emergence) and 14 DAE, 7 and 21 DAE, 14 and 28 DAE, and 7 and 28 DAE reduced peanut plant growth more than single applications. Paraquat applied at 21 DAE, Emergence and 14 DAE, 7 and 21 DAE, and 14 and 28 DAE reduced peanut yield when compared with pendimethalin at 0.84 kg ha-1 applied preplant incorporated (PPI). Peanut grade was not affected by any paraquat treatments. Tank mixes of paraquat + bentazon resulted in less peanut stunting than paraquat alone and treatment yields did not differ from the pendimethalin treatment.

KEYWORDS: groundnut, herbicide injury, peanut quality

Postemergence over-the-top applications of paraquat (1,1'-dimethyl-4-,4'-bipyridinium ion) are widely used for broadleaf weed control in peanuts (*Arachis hypogaea* L.) in the Southeastern U.S. (Wilcut et al., 1995). Paraquat has been an effective herbicide when applied within 3 weeks of crop emergence or ground cracking (Wehtje et al., 1986; Wilcut et al., 1989). Ground cracking is the term applied to the period between hypocotyl emergence and the appearance of the first true leaves (Boote, 1982).

Peanuts are tolerant to paraquat if applications are made prior to pegging and fruit development (Wilcut and Swann, 1990), which is approximately 5 weeks after emergence (Wehtje et al., 1986). Tolerance at this stage has been attributed to the size and nutrient reserves of the seed (Schroeder and Warren, 1971). Peanut tolerance to paraquat is not cultivar dependent (Knauft et al., 1990; Wehtje et al., 1991b) nor is it influenced by seed size (Wehtje et al., 1991b). Paraquat can be applied from crop emergence until 28 days after emergence (Anonymous, 1994). Paraquat applied after this 28-day period increases the chance of significant yield reductions (Wehtje et al., 1986; Brecke and Colvin, 1988).

Paraquat plus bentazon [3-(1-methylethyl)-1H)-2,1-3-benzothiadiazin-4(3H)-one 2,2-dioxide] mixtures control more broadleaf weed species than paraquat or bentazon alone, including bristly starbur (*Acanthospermum hispidum* D.C.), coffee senna (*Cassia occidentalis* L.), prickly sida (*Sida spinosa* L.), and smallflower morningglory [*Jacquemontia tamnifolia* (L.) Griseb.] (Wilcut et al., 1994). Bentazon also lessens paraquat-induced foliar injury to peanut by reducing paraquat absorption into peanut foliage (Wehtje et al., 1992). Although paraquat absorption also was reduced in several weed species,

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including Florida beggarweed [*Desmodium tortuosum* (S.W.) D.C.], sicklepod [*Senna obtusifolia* (L.)] Irwin & Barneby], and Texas panicum (*Panicum texanum* Buckl.) (Wehtje et al., 1991a; Wehtje et al., 1992) control of these species was not reduced unless the application was made to weeds larger than 5 cm tall.

Results with Virginia-type cultivars indicated that the application of paraquat to peanuts in a heavily infested weed area resulted in a significant yield decrease if the initial paraquat application was delayed past one week after peanut emergence (Wilcut and Swann, 1990). This yield decrease followed the decrease in common ragweed (*Ambrosia artemisiifolia* L.) control with the later application. They found that yields from treatments that utilized paraquat plus bentazon at 0.28 or 0.56 kg ha-1 were equivalent and did not differ from a preplant incorporated (PPI) treatment of ethalfluralin [N-ethyl-N-(2-methyl-2-propenyl)- 2,6-dinitro-4-(trifluoromethyl)benzenamine] at 0.84 kg ha-1 or ethalfluralin plus vernolate (S-propyl dipropylcarbamothioate) at 2.24 kg ha-1. However, no paraquat plus bentazon treatment provided yields equivalent to the weed-free control.

Very little paraquat is used in the Southwestern U.S. since many weeds are effectively controlled with PPI or preemergence (PRE) herbicides. Also, producers in the Southwestern U.S. are slow to accept any herbicide which injures peanut, delays flowering, and may lead to reduced yields (author's personal observation). Delayed development increases the risk from fall cold temperatures which may lead to freeze damage. However, weed escapes do occur and low cost herbicides such as paraquat are needed if research can show that their use causes no reduction in yield or quality.

All of the previously published research evaluating the use of paraquat in peanut was conducted in Alabama, Florida, Georgia, and Virginia where the predominant weed species are Florida beggarweed, sicklepod, Texas panicum, and pitted morningglory (*Ipomoea lacunosa* L.) and the peanut produced is primarily the 'Runner' or 'Virginia' type (Buchanan et al., 1982; Dowler, 1995; Sholar et al., 1995).

To date, no information has been published concerning the use of paraquat or paraquat and bentazon mixtures on runner-type peanuts grown in the Southwest. The objectives of this study were to evaluate paraquat or paraquat and bentazon mixtures and timing of application on runner-type peanut yield, injury, and grade.

MATERIALS AND METHODS

Experiments were conducted at the Texas Agricultural Experiment Station located near Yoakum during the 1989 and 1990 growing season on a Tremona loamy fine sand (thermic Aquic Arenic Paleustalfs) with less than 1% organic matter and a pH of 7.0 to 7.2. Areas with low weed populations were selected to reduce labor for hand weeding.

No general PPI herbicide was applied prior to planting since the area selected in each year of the study had very low weed populations. 'Florunner' peanut was planted 5 cm deep at the rate of 100 kg ha-1 in a well prepared seedbed using conventional equipment each year of the study.

Paraquat at 0.14 kg ha-1 alone or paraquat plus bentazon at 0.56 kg ha-1 were applied at the following times: peanut emergence (Emergence), 7 days after emergence (7 DAE), 14 days after emergence (14 DAE), 21 days after emergence (21 DAE), 28 days after emergence (28 DAE), and various combinations of those dates. Pendimethalin at 0.84 kg ha-1 was applied PPI with a tractor-driven power tiller as a standard treatment. A non-treated control was included also.

Herbicides were applied with a compressed air bicycle sprayer using SS11002 nozzles (Spraying Systems Co., North Ave. and Schmale Road, Wheaton, IL 60188) that delivered a spray volume of 190 Lha-1 at 180 kPa. All treatments included a nonionic surfactant (X- 77, a mixture of alkylaryl polyoxyethylene glycols, free fatty acids and isopropanol; Valent USA Corp., Box 8025, Walnut Creek, CA 94596) at 1% (vv-1).

A factorial arrangement of treatments in a randomized complete block design with four replications was used. Plot size was 2 rows spaced 97 cm apart and 6.3 m long. Peanut plant height measurements were taken 40 and 60 DAE to provide an index of crop injury. Plant heights were determined randomly from each plot at eight different locations within each plot. Peanut yields were determined by digging each plot separately, air drying in the field for 4 to 8 d, and harvesting peanuts from each plot with a combine. Weights were recorded after foreign material was removed from plot samples. Peanut grades were determined for a 250 g pod sample from each plot following procedures described by the U.S. Federal-State Inspection Service.

All data were evaluated with analysis of variance, and LSD at = 0.05 level of was calculated to compare treatment means. Data were evaluated individually by years because year by treatment effects were significant. Transformation did not change the results, so non-transformed data were analyzed and presented.

RESULTS AND DISCUSSION

Peanut plant growth. The 40 DAE measurements in 1989 indicated paraquat alone applied in a sequential application at 7 and 21 DAE, 14 and 28 DAE, or 7 and 28 DAE reduced peanut plant growth at least 18% when compared with the non-treated control (Table 1). The addition of bentazon to paraquat at these application timings resulted in no reduction in peanut plant growth compared to the non-treated control. No other herbicide applications reduced peanut plant growth.

In 1990, reductions in peanut plant growth 40 DAE were noted with paraquat alone applied at 7, 14, 21, and 28 DAE and all sequential applications of paraquat alone or paraquat and bentazon treatments (Table 1). Single applications of paraquat and bentzaon tank mixes did not reduce plant height. Wehtje et al. (1986) reported that Florunner canopy width was not reduced when paraquat was applied at the third week or sooner after peanut emergence. However, they stated that multiple paraquat applications were very injurious to late-planted peanuts.

The 60 DAE plant measurements in 1989 indicated plant height reductions compared to the non-treated control when paraquat was applied 14 DAE, paraquat and bentazon applied 21 DAE, or the sequential application of paraquat applied 7 and 28 DAE (Table 1). In 1990, sequential applications of paraquat applied at Emergence and 14 DAE, 7 and 21 DAE, 14 and 28 DAE, or 7 and 28 DAE reduced plant growth up to 18% when compared to the non-treated control (Table 1). No peanut plant size reduction occurred with the pendimethalin application in 1989 and 1990.

The interaction of paraquat with other herbicides has been variable. O'Sullivan and O'Donovan (1982) reported that the phytotoxicity of paraquat to barley (*Hordeum vulgare* L.) was not reduced when tank mixed with the ester formulations of 2,4-D [(2,4-dichlorophenoxy)acetic acid], MCPA [(4-chloro-2-methylphenoxy)acetic acid], or bromoxynil (3, 5-dibromo-4-hydroxybenzonitrile). However, dimethylamine formulations of either 2,4-D or MCPA were antagonistic. Subsequent work (O'Donovan and O'Sullivan, 1982) revealed that this antagonism was not evident if the phenoxy carboxylic acid herbicides were applied 1 day prior to application of paraquat.

Table 1. Peanut response to paraquat and paraquat plus bentazon mixtures applied up to 28 days after peanut emergence.

			Plant height (cm)						Peanut grade	
		Application	40 DAE[1]		60 DAE		Yield (kg ha^{-1})		(% SMK + SS)[2]	
Treatment	Rate (kg ha^{-1})	timing[1]	1989	1990	1989	1990	1989	1990	1989	1990
Check			29.9	31.5	37.3	36.8	4665	4503	73.3	69.8
Paraquat (P)	0.14	Emergence (E)	28.6	29.7	37.0	38.9	4718	4582	71.8	70.5
P+Bentazon (B)	0.14+0.56	Emergence (E)	31.8	30.0	35.8	36.6	4873	5169	72.0	71.0
P	0.14	7 DAE	27.9	25.4	33.0	35.1	4705	4629	69.8	69.5
P+B	0.14+0.56	7 DAE	30.2	29.2	35.3	37.6	4600	4621	73.5	70.3
P	0.14	14 DAE	28.7	26.9	30.7	33.0	4155	4281	68.8	69.3
P+B	0.14+0.56	14 DAE	27.7	29.2	34.0	36.7	4745	4304	70.0	69.8
P	0.14	21 DAE	27.9	25.9	33.3	33.0	3886	3718	69.8	69.8
P+B	0.14+0.56	21 DAE	25.9	28.7	31.0	36.3	5076	5169	70.8	70.0
P	0.14	28 DAE	26.2	27.9	33.3	33.5	4293	4768	70.5	70.0
P+B	0.14+0.56	28 DAE	28.2	29.7	35.6	36.3	4959	4252	70.8	69.3
P	0.14	E+14 DAE	26.9	25.7	34.0	32.0	4565	3953	71.0	70.8
P+B	0.14+0.56	E+14 DAE	29.7	26.2	35.6	35.1	4846	4420	69.5	70.5

Table 1. Continued

			Plant height (cm)						Peanut grade	
		Application	40 DAE[1]		60 DAE		Yield (kg ha^{-1})		(% SMK + SS)[2]	
Treatment	Rate (kg ha^{-1})	timing[1]	1989	1990	1989	1990	1989	1990	1989	1990
P	0.14	7+21 DAE	22.6	22.6	31.5	30.2	4176	3733	69.8	65.8
P+B	0.14+0.56	7+21 DAE	28.7	27.4	34.5	34.3	4480	4797	68.5	70.5
P	0.14	14+28 DAE	25.1	23.4	32.5	31.2	4147	3658	69.0	67.5
P+B	0.14+0.56	14+28 DAE	27.4	25.7	33.8	34.8	4002	4640	69.3	68.8
P	0.14	7+28 DAE	24.4	21.8	30.5	30.0	3830	4016	69.0	70.0
P+B	0.14+0.56	7+28 DAE	30.0	27.9	34.8	32.5	4441	4816	69.5	69.8
Pendimethalin	0.84	PPI	28.2	31.0	34.8	36.3	4447	5395	71.8	70.3
LSD (0.05)			4.5	2.8	5.8	4.6	929	1143	4.8	4.2

[1]DAE=days after peanut emergence; PPI=preplant incorporated

[2]SMK=sound mature kernels; SS=sound splits

They concluded that a chemical interaction between the dichloride salt of paraquat and the dimethylamine salts of MCPA and 2,4-D leads to the production of less active compounds (O'Donovan et al., 1983).

Peanut Yield

In 1989, paraquat and bentazon applied 21 DAE produced the highest yield, whereas paraquat alone applied 21 DAE or 7 and 28 DAE resulted in the lowest yields (Table 1). Peanut plant height 60 DAE was reduced with the paraquat and bentazon tank mix. No explanation can be given for the high yield associated with reduced peanut plant growth. In 1990, paraquat alone applied 21 DAE, Emergence and 14 DAE, 7 and 21 DAE, and 14 and 28 DAE produced significantly lower yields than the pendimethalin treatment.

Research in the Southeastern U.S. has shown that paraquat causes injury to the peanut foliage; however, the peanut plant rapidly recovers under good growing conditions and yield was unaffected (Wehtje et al., 1986; Brecke and Colvin, 1988; Wilcut et al., 1989; Wilcut and Swann, 1990). Wehtje et al. (1986) stated that paraquat application(s) can result in loss of peripheral leaves of the canopy; consequently, crop development can be temporarily delayed. Generally a peanut crop in the Southeastern U.S. will recover provided paraquat application was made to an actively growing crop prior to the main fruiting period, and sufficient time remains in the growing season for recovery (Brecke, 1983; Buchanan and Bryant, 1980).

Peanut Grade

In 1989 and 1990, no differences in peanut grade occurred between the non-treated control and any paraquat treatment (Table 1). In 1989, paraquat and bentazon applied at 7 and 21 DAE resulted in a lower grade than paraquat and bentazon applied 7 DAE, whereas in 1990, paraquat alone at 7 and 21 DAE resulted in a lower grade than several paraquat alone or paraquat and bentazon treatments.

CONCLUSION

The chance of paraquat causing peanut injury and subsequent yield reduction is greater in the Southwestern U.S. than the Southeastern U.S. due to the increased potential for poor growing conditions in the Southwestern U.S. Peanut growers in the Southwestern U.S. plant later in the year when air temperatures are higher than in the Southeastern U.S. The combination of higher temperature, lower humidities, and water stress may lead to more leaf damage and subsequent yield reduction. Producers in the Southwestern U.S. are slow to accept any herbicide which may cause peanut injury during poor growing conditions.

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