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WEED SCIENCE

Cotton Sensitivity to Pyrithiobac Applied Under Two Irrigation Regimes

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ABSTRACT

Broadleaf weed control is needed to optimize cotton (*Gossypium hirsutum* L.) yield. Pyrithiobac controls many broadleaf weeds in cotton when applied preemergence or postemergence. Research was conducted to determine if cultivar selection and early-season irrigation influenced cotton response to pyrithiobac at 70 or 140 g ai ha^{-1} applied postemergence or 70 g ha^{-1} applied preemergence followed by 70 g ha^{-1} applied postemergence. Injury was greater when pyrithiobac was applied postemergence over-the-top at 140 g ha^{-1} than at 70 g ha^{-1}, irrespective of cultivar. For most cultivars, pyrithiobac at 140 g ha^{-1} postemergence over-the-top was more injurious than when applied preemergence at 70 g ha^{-1} followed by pyrithiobac at 70 g ha^{-1} postemergence over-the-top. Cotton was injured more when pyrithiobac was applied 1 d following 4 cm of irrigation than when this irrigation treatment was not applied, regardless of pyrithiobac rate. Although some differences in seed cotton yield were noted among pyrithiobac treatments, cultivar selection and early-season irrigation did not affect seed cotton yield.

Prior to registration of pyrithiobac and development of herbicide-resistant cotton cultivars, herbicides such as fluometuron and MSMA were applied postemergence over-the-top to control broadleaf weeds, as well as yellow nutsedge (*Cyperus esculentus* L.) and purple nutsedge (*Cyperus purpurea* L.). These herbicides often injured cotton, delayed fruit maturity, and reduced yield (Byrd and York, 1987; Guthrie and York, 1989; Snipes and Byrd, 1994). In contrast, adequate crop safety following postemergence over-the-top application of pyrithiobac is well established in the literature (Bryson et al., 1991; Crowder et al., 1992; Harrison et al., 1996; Jordan et al., 1993; Keeling et al., 1993; Shankle et al., 1996). Cotton tolerance to pyrithiobac applied premergence or postemergence over-the-top results from rapid metabolism of pyrithiobac into non-phytotoxic compounds (Crowder et al., 1992).

Plant stresses, such as cool temperatures, which inhibit the enzyme acetolactate synthase (E.C.4.1.3.18), limit the ability of cotton to rapidly metabolize herbicides like pyrithiobac and increase injury potential (Harrison et al., 1996). Correlations between temperature and pyrithiobac efficacy have been developed to improve recommendations on use (Light et al., 1999, 2001). Practitioners also indicate that applying pyrithiobac when soils are wet may enhance injury potential. Although not documented, it is suspected that metabolism of pyrithiobac may be minimized enough under wet soil conditions to influence tolerance. This relationship for pyrithiobac has not been established in the literature, but Newsom et al. (1992) and Miller and Griffin (1993) reported greater injury and lower soybean [*Glycine max* (L.) Merr.] yield when imazapic was applied under wet soil moisture conditions. The mechanism of action of imazapic is similar to pyrithiobac (Crowder et al., 1992; Miller and Griffin, 1993). Research also indicates that pyrithiobac injures bromoxynil-resistant cultivars more than non-transgenic or glyphosate-resistant cultivars (Smith et al., 1996). Determining if injury potential is greater when pyrithiobac is applied when soil is wet will be important in developing weed management strategies. Defining the cultivars that are more prone to injury from pyrithiobac is also important. Research

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was conducted to compare the response of cotton cultivars following preemergence and postemergence over-the-top applications of pyrithiobac under two early-season irrigation regimes.

MATERIALS AND METHODS

Field experiments were conducted in 1997 and 1998 at the Macon Ridge Branch of the Northeast Research Station located near Winnsboro, LA on a Gigger silt loam soil (fine-silty, mixed, active, thermic, Typic Fragiudalf) with 1.3% organic matter at pH 5.6. Cotton was established at 9 to 10 plants per meter of row in conventionally tilled seedbeds in early May of each year. Plot size was 2 rows (spaced 1 m apart) by 5 m. Trifluralin [Treflan, 2,6-dinitro-*N*,*N*-dipropyl-4-(trifluoromethyl)benzeneamine, Dow AgroSciences, Indianapolis, IN] at 0.84 kg ai ha^{-1} preplant incorporated followed by fluometuron {Cotoran, *N*,*N*-dimethyl-*N*'[-3-(trifluoromethyl)phenyl]urea, Syngenta Crop Protection, Greensboro, NC} at 1.1 kg ai ha^{-1} preemergence (PRE) were applied over the entire test area. Escaped weeds were controlled throughout the season by hand-removal and cultivation. Aldicarb [Temik 15G, 2-methyl-2-(methylthio)propionaldehyde *O*-(methylcarbamoyl)oxime, Bayer CropScience, Research Triangle Park, NC] was applied at 5.6 kg ai ha^{-1} in the seed furrow at planting. Insect management strategies and production practices were the same over the entire test and were based on recommendations by the Louisiana Cooperative Extension Service.

The sodium salt of pyrithiobac [Staple, sodium 2-chloro- (4,5-dimethoxypyrimidin-2-ylthio)benzoate, DuPont Agricultural Products, Wilmington, DE] was applied postemergence over-the-top (POT) at 70 g ha^{-1} or 140 g ha^{-1} and at 70 g ha^{-1} PRE followed by 70 g ha^{-1} POT. A nonionic surfactant at 0.25% (v/v) was included when pyrithiobac was applied POT. POT applications were made when cotton was 7 to 14 cm in height with 2 to 4 nodes. A no-herbicide control was included. Irrigation regimes included 2 cm of overhead sprinkler irrigation 3 d prior to POT applications or 2 cm of irrigation 3 d prior to POT applications followed by 4 cm of irrigation 1 d prior POT applications of pyrithiobac. Water was not standing when pyrithiobac was applied. No attempt was made to quantify soil moisture potential. The cotton cultivars included were as follows: Deltapine (DP) 20, DP 50, DP 5409, DP 5415, and DP 5415RR from Delta and Pine Land Seed Co. (Scott, MS); Hartz 1244RR and Hartz 1330RR from Hartz Seed Co. (Stuttgart, AR); Stoneville BXN 47, Stoneville BXN 57, Stoneville 474, Stoneville 495, and Stoneville LA 887 from Stoneville Pedigree Seed Co. (Stoneville, MS); and Sure-Grow 125 and Sure-Grow 501 from Delta and Pine Land Seed Co. (Scott, MS). The experimental design was a split-split plot with soil moisture serving as the whole plot unit, cultivar serving as the sub-plot unit, and pyrithiobac treatments serving as sub-sub plot units

Visual estimates of percentage cotton injury were recorded 7, 14, and 28 d after POT application of pyrithiobac (DAT) using a scale of 0 to 100% where 0 = no injury and 100 = plant death. Chlorosis, necrosis, and plant stunting were considered when making the visual estimates. Cotton was machine-harvested with a spindle picker in early October 1997 and late September 1998.

Data for visual estimates of cotton injury and seed cotton yield were subjected to analysis of variance for a two (year) by two (irrigation regime) by four (pyrithiobac treatment) by 14 (cultivar) factorial arrangement of treatments. Means of significant main effects and interactions were separated using Fisher's Protected LSD Test at $P = 0.05$. Appropriate error terms were used to calculate LSD values based on the split-split plot experimental design (McIntosh, 1984).

RESULTS AND DISCUSSION

Year by irrigation regime by pyrithiobac treatment, cultivar by pyrithiobac treatment, and irrigation regime by cultivar interactions were significant for cotton injury 7 DAT. Although symptoms included some plant stunting, injury was composed primarily of leaf chlorosis typical for herbicides that inhibit the enzyme acetolactate synthase (Crowder et al., 1992; Jordan et al., 1993; Smith et al., 1996). When pooled over cultivars, cotton injury 7 DAT when cotton was not irrigated before POT application was 10 to 17% in 1997 and 8 to 12% in 1998 (Table 1). In contrast, cotton injury at 7 DAT was 18 to 25% in 1997 and 13 to 23% in 1998 when cotton was irrigated 1 d before POT application. During both years, cotton injury was greater when pyrithiobac was applied POT at 140 g ha^{-1} compared with 70 g ha^{-1} POT or sequential applications of 70 g ha^{-1} regardless of irrigation regime. Although visual estimates of cotton injury were not recorded prior to POT application, there appeared to be no difference in cotton growth when comparing the non-treated cotton and cotton treated with pyrithiobac PRE. Additionally, injury was greater with sequential applications of pyrithiobac for a combined rate of 140 g ha^{-1} compared with pyrithiobac POT applied at 70 g ha^{-1} in 1997. Injury was similar for these treatments in 1998.

When pooled across years and irrigation regimes, cotton injury 7 DAT for pyrithiobac at 140 g ha^{-1} was greater than injury when pyrithiobac was applied POT at 70 g ha^{-1} for all cultivars (Table 2). With the exception of Stoneville 474, pyrithiobac was more injurious when applied POT at 140 g ha^{-1} compared with sequential applications of pyrithiobac at 70 g ha^{-1}. Differences were also noted among cultivars within irrigation regimes. When cotton was not irrigated prior to pyrithiobac POT, injury 7 DAT was 6 to 8% for the cultivars DP 5415, DP 5415RR, Hartz 1244RR, Hartz 1330RR, Stoneville 474, Stoneville 495, Stoneville LA 887, and Sure-Grow 501 (Table 2). Injury under this irrigation regime was 9 to 13% for the cultivars DP 20, DP 50, DP 5409, Stoneville BXN 47, Stoneville BXN 57, and Sure-Grow 125. When cotton was irrigated 1 d before pyrithiobac POT, injury ranged from 9 to 20%. The cultivar Stoneville BXN 57 was injured more than the other cultivars under this irrigation regime. When comparing individual cultivars across irrigation regimes, greater injury was noted when cotton was irrigated 1 d before pyrithiobac was applied POT for all cultivars except DP 50 and Stoneville BXN 47. For these cultivars, injury was 10 to 12% and 12 to 13%, respectively. Smith et al. (1996) reported 37% injury for the cultivar Stoneville BXN 57 compared with 10 to 17% for the cultivars Coker 315, Stoneville 132, and Stoneville 474 when pyrithiobac was applied sequentially (PRE followed by POT) at 70 g ha^{-1}. In our study, injury was 17% for Stoneville BXN 57 versus 12% for Stoneville 474 when pooled over years and pyrithiobac treatments (data not presented).

When evaluated 14 DAT, interactions of year by pyrithiobac treatment and irrigation regime by pyrithiobac treatment were significant. When pooled over cultivars and irrigation regimes, injury in 1997 was less than 6% and was greater when pyrithiobac was applied at 140 g ha^{-1} either as a single POT application or as sequential PRE followed by POT application compared with a single pyrithiobac application POT at 70 g ha^{-1} (Table 3). In 1998, pyrithiobac at 140 g ha^{-1} applied POT was the most injurious of the pyrithiobac treatments, but was only 8%. Regardless of the irrigation regime, injury was greater when pyrithiobac at 140 g ha^{-1} was applied POT compared with the other pyrithiobac treatments. Additionally, pyrithiobac was more injurious 14 DAT when cotton was irrigated 1 d prior to pyrithiobac applied POT, regardless of pyrithiobac treatment. No difference in cotton injury was noted among cultivars, pyrithiobac treatments, and irrigation regimes 28 DAT (data not presented).

The interaction of year by pyrithiobac treatment was significant for seed cotton yield. When pooled over irrigation regimes and cultivars, yield in 1997

Table 1. Effect soil moisture regime on pyrithiobac applied postemergence over-the-top (POT) and preemergence (PRE) on cotton injury 7 days after treatment

Rate (g ha^{-1}) and application method	Cotton injury (%)[x]			
	1997		1998	
	Non-irrigated	Irrigated[y]	Non-irrigated	Irrigated
70 POT	10	18	8	14
140 POT	17	25	12	23
70 PRE followed by 70 POT	13	22	8	13
LSD (P = 0.05)[z]	———— 2 ————		———— 2 ————	

[x] Visual estimates of percentage cotton injury are based on chlorosis, necrosis, and stunting using on scale of 0 to 100%, where 0 = no injury and 100% = plant death.

[y] Irrigation regimes consisted of 2 cm of sprinkle irrigation 3 d prior to POT application of pyrithiobac followed by 4 cm of sprinkle irrigation 1 d prior to POT application of pyrithiobac or 2 cm of sprinkle irrigation 3 d prior to POT application of pyrithiobac with no additional sprinkler irrigation prior to pyrithiobac application.

[z] The LSD can be used to compare means for pyrithiobac treatments within and across irrigation regimes within a year. Data are pooled over cultivars.

Table 2. Influence of cultivar, pyrithiobac treatment, and soil moisture regime on cotton injury 7 days after treatment with pyrithiobac applied postemergence over-the-top (POT) and preemergence (PRE)

Cultivar	Cotton injury (%)[x]				
	Pyrithiobac (g ha^{-1})			Non-irrigated	Irrigated[y]
	70 POT	140 POT	70 PRE fb 70 POT		
Deltapine 20	15	19	15	9	15
Deltapine 50	13	18	13	10	12
Deltpine 5409	13	22	17	9	17
Deltpine 5415	14	19	13	8	15
Deltapine 5415RR	13	20	16	7	17
Hartz 1244RR	11	17	14	8	13
Hartz 1330RR	11	17	13	7	14
Stoneville BXN 47	13	21	16	12	13
Stoneville BXN 57	19	29	18	13	20
Stoneville 474	8	12	10	6	9
Stoneville 495	9	15	10	6	11
Stoneville LA887	13	20	15	8	15
Sure-Grow 125	14	22	14	10	15
Sure-Grow 501	14	20	15	8	16
LSD (P = 0.05)[z]		3		3	

[x] Visual estimates of percentage cotton injury are based on chlorosis, necrosis, and stunting using on scale of 0 to 100%, where 0 = no injury and 100% = plant death.

[y] Irrigation regimes consisted of 2 cm of sprinkle irrigation 3 d prior to POT application of pyrithiobac followed by 4 cm of sprinkle irrigation 1 d prior to POT application of pyrithiobac or 2 cm of sprinkle irrigation 3 d prior to POT application of pyrithiobac with no additional sprinkler irrigation prior to pyrithiobac application.

[z] The LSD can be used to compare means for pyrithiobac treatments within and across irrigation regimes within a year. Data are pooled over cultivars.

Table 3. Effect of year and irrigation regime on pyrithiobac applied postemergence over-the-top (POT) and preemergence (PRE) on cotton injury 14 days after treatment

Rate (g ha^{-1}) and application method	Cotton injury (%)[x]			
	1997	1998	Non-irrigated	Irrigated[y]
70 POT	3	4	2	5
140 POT	6	8	5	9
70 PRE followed by 70 POT	6	5	4	7
LSD (P = 0.05)[z]	1		1	

[x] Visual estimates of percentage cotton injury are based on chlorosis, necrosis, and stunting using on scale of 0 to 100%, where 0 = no injury and 100% = plant death.

[y] Irrigation regimes consisted of 2 cm of sprinkle irrigation 3 d prior to POT application of pyrithiobac followed by 4 cm 1 d prior to POT application of pyrithiobac or 2 cm of sprinkle irrigation 3 d prior to POT application of pyrithiobac with no additional sprinkler irrigation prior to pyrithiobac application.

[z] The LSD can be used to compare means for pyrithiobac treatments within and across irrigation regimes within a year. Data are pooled over cultivars.

was similar when pyrithiobac was applied at 70 g ha^{-1} POT and as single or sequential applications (Table 4). Yield for sequential applications of pyrithiobac was lower than that following a single POT application of pyrithiobac at 140 g ha^{-1} or non-treated cotton in 1997. These differences could not be explained by differences in early season injury noted among treatments. In 1998, pyrithiobac did not affect yield when compared with the no-herbicide control. In previous research, pyrithiobac applied under weed-free conditions has shown no effect on cotton yield (Harrison et al., 1996; Jordan et al. 1993; Keeling et al., 1996). Lack of pyrthiobac by year by irrigation regime by cultivar interaction allowed pooling of data over 14 cultivars for yield, and this increased precision of making treatment comparisons.

Table 4. Effect of pyrithiobac applied postemergence over-the-top (POT) and preemergence (PRE) on seed cotton yield

Rate (g ha^{-1}) and application method	Seed cotton (kg ha^{-1})	
	1997	1998
70 POT	4020	2080
140 POT	4090	2020
70 PRE followed by 70 POT	3950	2100
Non-treated	4170	2110
LSD (P = 0.05)[z]	——————100——————	

[z] The LSD can be used to compare means within pyrithiobac treatments and across years. Data are pooled over cultivars and irrigation regimes.

Results from this research indicate that early season injury by pyrithiobac may be more likely when cotton is irrigated shortly before POT applications. Similarly, these data indicate that wet soils resulting from rainfall within several days prior to application of pyrithiobac POT may contribute to greater cotton injury from pyrithiobac. Greater early season injury under wet soil conditions was not reflected in differences in seed cotton yields. Although some differences in cultivar response to pyrithiobac POT, these differences were not reflected in cotton yield.

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