Impact of Insecticides Applied With/Without Bromoxynil Herbicide on Various Cotton Pests in Laboratory Bioassays[1]

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ABSTRACT Spray chamber tests with BXN cotton, *Gossypium hirsutum* (L.), plant terminals demonstrated that mixing bromoxynil herbicide with different classes of insecticides had no negative effects on the efficacy of the insecticides for boll weevils, *Anthonomus grandis grandis* (Boheman), tarnished plant bugs, *Lygus lineolaris* (Palisot de Beauvois), or tobacco budworms, *Heliothis virescens* (F.). Efficacy of azinphos-methyl for control of tarnished plant bugs was significantly increased at 48 h when mixed with bromoxynil. A significant decrease in survival of the tobacco budworm occurred at 24 h when cyfluthrin was mixed with bromoxynil. Bromoxynil can be applied for weed control in cotton as early as the seedling stage. The ability to mix a herbicide with an insecticide can save on application costs.

KEY WORDS Bromoxynil, boll weevil, tobacco budworm, tarnished plant bug, BXN cotton

A transgenic cotton (BXN, Rhone Poulenc and Stoneville Pedigreed Seed Co.) with resistance to the broad leaf herbicide, bromoxynil, has received a conditional registration as announced in 29 March 1995 Federal Register Notice. Studies by Crawford (1993) showed that two post-emergence over-the-top applications of bromoxynil at elevated rates of 1.68 kg [AI]/ha were made without foliar injury to BXN cotton. Baldwin et al. (1992) reported no yield impacts following one or two applications of bromoxynil to two transgenic cotton strains. Yield of the two strains did not differ from parent varieties. Richburg et al. (1993) and Grey et al. (1993) reported the effectiveness of bromoxynil in controlling several broadleaf weeds in cotton. Wilcut et al. (1993) indicated that bromoxynil and BXN cotton would provide cotton producers with a valuable tool to control unacceptable weeds. Bromoxynil herbicide was used on as many as 20,243 ha of BXN cotton in 1995 and will be used on as many as 100,000 to 105,000 ha in 1996. The maximum use rate for bromoxynil was set at 1.68 kg [AI]/ha for the season (three applications at 0.56 kg [AI]/ha). Producers will be able to use bromoxynil to control weeds in cotton as early as the seedling stage.

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The purpose of the study reported here was to determine if various insecticides remained effective against cotton insect pests when mixed and applied with bromoxynil. If so, it would provide cotton producers growing BXN cotton the opportunity to mix an over-the-top herbicide with a needed insecticide; thus saving on application costs.

Materials and Methods

Several insecticides (representing pyrethroid, carbamate, organophosphate and biological classes of insecticides) recommended for cotton insect control were applied to BXN cotton terminals utilizing a laboratory spray chamber described by Elzen et al. (1987, 1989). The spray chamber was calibrated to deliver a total volume of 94 L/ha. Tarnished plant bugs used in the study were exposed to Penncap-M® 2F (encapsulated methyl parathion, Elf AtoChem, Philadelphia, PA), Guthion® (azinphos-methyl, Bayer Corporation, Kansas City, MO), Vydate® (oxamyl, Bayer Corporation, Kansas City, MO), and Dimethoate® (dimethoate, Helena Chemical Co., Memphis, TN) (0.14, 0.14, 0.14 and 0.14 kg [AI]/ha, respectively); boll weevils were exposed to encapsulated methyl parathion, azinphos-methyl, and oxamyl (0.14, 0.14 and 0.14 kg [AI]/ha, respectively; and tobacco budworms were exposed to Condor® (*Bacillus thuringiensis* Berliner, Ecogen Corporation, Philadelphia, PA), Baythroid® (cyfluthrin, Bayer Corporation, Kansas City, MO), Larvin® 3.2F, (thiodicarb, Rhone Poulenc Ag, Research Triangle Park, NC), and Curacron® (profenofos, Ciba Crop Protection, Greensboro, NC) (585 ml/ha and 0.03, 0.54 and 0.74 kg [AI]/ha, respectively).

Tarnished plant bugs and tobacco budworms were obtained from laboratory colonies maintained at the Southern Insect Management Laboratory (Stoneville, MS) and boll weevils were from the Gast Rearing Facility (Mississippi State, MS). Each group of insect pests were exposed to mixtures of the insecticide alone and in combination with bromoxynil at 1.68 kg [AI]/ha. An untreated check and a bromoxynil-only check were included with each insect species tested. Each treatment was replicated three times with 10 cages/replication. After plants were treated and allowed to dry, 3 boll weevils or plant bugs were placed on each terminal, and each plant was covered with a 590-ml ventilated cup. In tests with tobacco budworms, only one third-instar larva was placed in each cage. A constant temperature of 26°C and relative humidity of 70% with 12 h light were maintained throughout the 48-h test period.

The experimental design was a randomized complete block, and treatment structure was a factorial with two levels of bromoxynil and four or five levels of insecticides used to test each insect species. Data were analyzed using analysis of variance (SAS Institute 1987), and means were separated using least significant difference (LSD) (P = 0.05). The interaction between bromoxynil and the insecticide treatments was tested to determine if survival was affected for each insect species tested.

Results and Discussion

The interaction between bromoxynil and the insecticides for tarnished plant bugs at 24 h was not significant ($F = 0.69$; df = 4, 81; $P = 0.690$), which showed that bromoxynil affected all insecticides tested equally. The use of bromoxynil caused a decrease in mean survival of plant bugs in all treatments (except the encapsulated methyl parathion) (Table 1), and the test for the main effect of bromoxynil was significant ($F = 4.14$; df = 1, 81; $P = 0.045$). The test for the main effect of insecticides also was significant ($F = 42.12$; df = 4, 81; $P = 0.001$), and means for all treatments with and without bromoxynil are shown (Table 1). Mean survival in the oxamyl and dimethoate treatments was significantly lower than mean survival in the control, bromoxynil, encapsulated methyl parathion, and azinphos-methyl treatments. However, the significant differences in the dimethoate and azinphos-methyl treatments with and without bromoxynil should be ignored because of the lack of a significant interaction between bromoxynil and the insecticides. At 48 h after treatment, there was a significant interaction between bromoxynil and the insecticides ($F = 3.89$; df = 4, 81; $P = 0.001$). The insecticide most affected by the addition of bromoxynil was azinphos-methyl; survival in this treatment at 48 h was significantly lower than survival in the treatment without bromoxynil.

Significant differences were found in mean survival of boll weevils in the insecticide treatments at 24 h ($F = 281.27$; df = 3, 63; $P = 0.0001$) and at 48 h ($F = 1287.34$; df = 3, 63; $P = 0.0001$) (Table 2). However, for both time periods the differences were only in mean survival in the control as compared to all other insecticide treatments. The interaction between bromoxynil and the insecticides was not significant at 24 h ($F = 1.03$; df = 3, 63; $P = 0.384$) or 48 h ($F = 0.40$; df = 3, 63; $P = 0.756$).

The bromoxynil by insecticide interaction was significant ($F = 3.78$; df = 4, 81; $P = 0.007$) for survival of tobacco budworm larvae at 24 h. The main treatment affected by bromoxynil was cyfluthrin. Survival of tobacco budworm larvae was significantly lower in this treatment with bromoxynil as compared to the cyfluthrin treatment without bromoxynil (Table 3). Along with the cyfluthrin plus bromoxynil treatment, the thiodicarb and profenofos treatments alone and in combination with bromoxynil had significantly lower survival of tobacco budworm larvae than was found in all other treatments at 24 h after treatment. At 48 h after treatment, the bromoxynil by insecticide interaction was not significant ($F = 1.33$; df = 4, 81; $P = 0.265$). The lack of a significant bromoxynil by insecticide interaction at 48 h was not surprising because of the low number of larvae that survived the cyfluthrin, thiodicarb, and profenophos treatments (with and without bromoxynil) after 24 h. Significant differences in survival in the treatments ($F = 103.19$; df = 4, 81; $P = 0.0001$) were found at 48 h, but these were mainly between the insecticide treatments with and without bromoxynil and the control or bromoxynil treatments. A significantly higher number of tobacco budworm larvae survived in the *B. thuringiensis* treatment with bromoxynil as compared to this treatment without bromoxynil, but this difference should be ignored because of the lack of a significant interaction between bromoxynil and the insecticides at 48 h.

Table 1. Mean survival of tarnished plant bugs caged on treated cotton terminals with three adults per cage.

Treatment	Rate [kg (AI) ha]	Mean survival 24 h	Mean survival 48 h
Control	0.00	2.90 a	2.60 a
Bromoxynil	1.68	2.70 ab	2.20 a
Encapsulated methyl parathion	0.14	2.80 ab	2.60 a
Encapsulated methyl parathion + bromoxynil	0.14 + 1.68	2.90 a	2.10 a
Azinphos-methyl	0.14	3.00 a	2.10 a
Azinphos-methyl + bromoxynil	0.14 + 1.68	2.40 b	0.60 b
Oxamyl	0.14	1.20 c	0.30 b
Oxamyl + bromoxynil	0.14 + 1.68	0.90 c	0.20 b
Dimethoate	0.14	0.90 c	0.40 b
Dimethoate + bromoxynil	0.14 + 1.68	0.40 d	0.10 b
LSD		0.415	0.551

Means in a column not followed by a common letter are significantly different (LSD; $P \leq 0.05$).

Table 2. Mean survival of laboratory weevils caged on treated cotton terminals with three adults per cage.

Treatment	Rate [kg (AI) ha]	Mean survival 24 h	Mean survival 48 h
Control	0.00	300 a	2.90 a
Bromoxynil	1.68	3.00 a	2.80 a
Encapsulated methyl parathion	0.14	0.10 b	0.00 b
Encapsulated methyl parathion + bromoxynil	0.14 + 1.68	0.30 b	0.00 b
Oxamyl	0.14	0.30 b	0.00 b
Oxamyl + bromoxynil	0.14 + 1.68	0.10 b	0.00 b
Azinphos-methyl	0.14	0.20 b	0.00 b
Azinphos-methyl + bromoxynil	0.14 + 1.68	0.10 b	0.00 b
LSD		0.237	0.158

Means in a column not followed by a common letter are significantly different (LSD; $P \leq 0.05$).

Table 3. Mean survival of tobacco budworm caged on treated cotton terminals with one larvae per cage.

Treatment	Rate [kg (AI) ha]	Mean survival	
		24 h	48 h
Control	0.00	1.00 a	1.00 a
Bromoxynil	1.68	1.00 a	0.90 a
Condor	8 oz	1.00 a	0.70 b
Condor + bromoxynil	8 oz + 1.68	1.00 a	0.90 a
Cyfluthrin	0.03	0.40 b	0.00 c
Cyfluthrin + bromoxynil	0.03 + 1.68	0.00 c	0.00 c
Thiodicarb	0.54	0.10 c	0.00 c
Thiodicarb + bromoxynil	0.54 + 1.68	0.00 c	0.00 c
Profenofos	0.74	0.00 c	0.00 c
Profenofos + bromoxynil	0.74 + 1.68	0.10 c	0.00 c
LSD		0.196	0.188

Means in a column not followed by a common letter are significantly different (LSD; $P \leq 0.05$).

The results of the spray chamber tests indicated that there were no negative effects from mixing bromoxynil with the various insecticides. Efficacy with azinphos-methyl on the tarnished plant bug and cyfluthrin on tobacco budworm were enhanced with bromoxynil. The insecticides used in the test are representative of the major classes; therefore, based on the findings reported here, we believe it is possible to apply bromoxynil with most insecticides recommended for control of cotton pests.

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