IMPACT OF RAINFALL ON COTTON INSECT MANAGEMENT WITH INSECTICIDES

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Abstract

An important component of cotton production in the Mid-South is insect pest management. Cotton growers depend heavily on foliar applied insecticides as a part of their management strategy. Heavy pest pressures during the cotton growing season may also be accompanied by unpredictable rainfall. Performance of common insecticides and their efficacy after a rainfall event are not well known. Field and laboratory studies were conducted in 2019 and 2020 to determine the impact of simulated rainfall on insecticides commonly used for tarnished plant bug, *Lygus lineolaris* (Palisot de Beauvois), control. Chemical analyses were conducted in 2019 by spraying plots with insecticide, simulating rainfall, and collecting leaves to undergo a residue plant tissue analysis. Water pick bioassays were conducted in 2020 by spraying terminals, simulating rainfall, and infesting terminals with live adult plant bugs. All of the insecticides evaluated were negatively impacted by rainfall, novaluron was the product that was least impacted by simulated rainfall.

Introduction

The tarnished plant bug, *Lygus lineolaris* (Palisot de Beauvois), is an important pest of cotton. Tarnished plant bug populations can build up to large numbers before moving into cotton because of their broad host range (Young 1986). Layton (1995) observed that tarnished plant bug numbers may be especially high in years with more precipitation because alternative hosts remain in bloom longer. This species feeds on fruiting forms, such as squares and bolls (Strong 1968; Wilson and George 1984; Leigh et al. 1988) and may cause those structures to abscise. Cotton is especially susceptible to damage from tarnished plant bug during the reproductive stages. Heavy pressure in cotton often aligns with those months that receive a lot of rainfall. Additionally, most insecticide manufacturers do not provide any information on the rainfastness of their products.

Two studies conducted by Willis et al. (1994a &1994b) showed that insecticides were more resistant to wash off as time between application and rainfall increased. The authors suggest this could be attributed to more time allowed for plants to absorb the insecticide. The conclusions of this experiment were to postpone insecticide application if rainfall is expected. McDowell et al. (1984) found that quantity of rainfall had a greater impact on wash off than intensity of rainfall. Mulrooney and Elmore (2000) found that even when using adjuvants, insecticides will perform better when allowed more time between insecticide application and rainfall. The objective of the current experiment was to evaluate the impact of rainfall on insecticides commonly used to control tarnished plant bug in cotton.

Materials and Methods

Field and laboratory studies were conducted in 2019 and 2020 in Stoneville, MS to evaluate the efficacy of insecticides after a rainfall event. Collections of tarnished plant bugs were made from marestail (*Conyza canadensis*) to be used in bioassays. Water pick bioassays were conducted by collecting clean cotton terminals and placing them in 15mL centrifuge tubes and sealing them with a rubber cap which had a small opening for the stems. Tubes were held upright using plastic cup lids and setting them inside wooden racks. Terminals were sprayed with field rates of insecticides: acephate (0.756kg ai/ha), dicrotophos (0.56kg ai/ha), thiamethoxam (0.07kg ai/ha), sulfoxaflor (0.053kg ai/ha), and novaluron (0.045kg ai/ha). Treatments included an untreated control, insecticide with no simulated rainfall, and timed simulated rainfall treatments (1, 2, 4, 8, and 16 hours after application). Water picks were placed under a rainfall simulator for approximately 5-8 minutes until 2.54cm of simulated rainfall was collected in the rain gauge. Terminals were infested with two adult tarnished plant bugs, or nymphs in the case of novaluron, and sealed using a plastic cup fitted to the plastic lid. Mortality of tarnished plant bug adults were recorded at two days after treatments and nymph mortality was recorded at three days after treatment. Data were analyzed using SAS PROC GLIMMIX and PROC MEANS procedure.

Chemical analyses were performed in 2019 by spraying plots arranged in a randomized complete block design. Experiments were run on acephate (Orthene 90 SP, Amvac Chemical Corporation, Los Angeles, CA), dicrotophos (Bidrin® 8E, Amvac Chemical Corporation, Newport Beach, CA), thiamethoxam (Centric 40WG, Syngenta Crop Protection, Greensboro, NC) sulfoxaflor (Transform WG, Dow AgroScience, Indianapolis, IN), and novaluron (Diamond 0.83EC, ADAMA USA, Raleigh, NC). Field rates of each product were sprayed: acephate (0.756kg ai/ha), dicrotophos (0.56kg ai/ha), thiamethoxam (0.07kg ai/ha), sulfoxaflor (0.053kg ai/ha), and novaluron (0.045kg ai/ha). Rainfall was simulated using a square pattern sprinkler (#7800, Melnor Inc., Winchester, VA) mounted on a tripod placed at the center of each plot. Tripod position was marked using wire flags to ensure samples received rainfall. Each plot received approximately 2.54cm of rainfall. After drying, leaves were pulled and stored in self-sealing plastic bags and placed in the freezer. Samples were taken to the Mississippi State University Chemical Laboratory for analysis. Samples were crushed and put through a series of centrifugation to extract the insecticide. The insecticide extraction was analyzed using an Agilent Technologies 6460 Triple Quad LC/MS. The mass spectrometer provided a concentration reading of insecticide in parts per billion.

Results and Discussion

Water pick bioassays conducted in 2020 showed that simulated rainfall had a significant effect on the performance of dicrotophos ($F=9.5$; $df=6, 21$; $P<0.01$), thiamethoxam ($F=43.27$; $df=6, 18$; $P<0.01$), acephate ($F=79.8$; $df=6, 21$; $P<0.01$), sulfoxaflor ($F=47.28$; $df=6, 21$; $P<0.01$), and novaluron ($F=10.82$; $df=5, 15$, $P<0.01$).

Dicrotophos mortality was the same among simulated rainfall timings with the exception of the no simulated rainfall treatment and the 8-hour treatment timing. The 8-hour timing was the only treatment timing which separated from the untreated control, but still did not provide similar results as the no simulated rainfall treatment. Thiamethoxam had no treatments that were different from the untreated control, except the no simulated rainfall treatment. Acephate mortality of treatment timings were all similar to the untreated control. Sulfoxaflor had only one timing treatment (4 hours) that differed from the untreated control. However, this timing still did not provide similar results to the no simulated rainfall treatment. Novaluron provided one treatment timing (8 hours) that provided similar results to the no simulated rainfall control. The remaining treatments provided similar mortality to the untreated control.

Chemical analyses conducted in 2019 showed that rainfall has a significant effect on the concentration of thiamethoxam ($P<0.01$), acephate ($P<0.01$), sulfoxaflor ($P<0.01$), and novaluron ($P<0.01$).

Analyses of thiamethoxam showed that no treatments had concentrations comparable to the no simulated rainfall treatment. One treatment, 4 hours, provided higher concentrations than the 0-minute timing. Acephate analyses showed no treatments with concentrations comparable to the no simulated rainfall treatment. Analyses of sulfoxaflor also had no treatment timings with concentrations similar to the no simulated rainfall treatment. Novaluron results showed one treatment timing with concentrations similar to the no simulated rainfall treatment. In addition, the 6, 120, and 240-minute timings provided higher concentrations than the 0-minute timing.

Summary

Further studies are needed to understand the rainfastness of commonly used insecticides to develop the best management strategy in the instance of unexpected rainfall. Foliar insecticides, next to Bt cotton, are a grower's best defense against insect pests. Pest pressures tend to be high during July, August, and September which are also months that receive sporadic rain showers.

Experiments conducted in 2020 showed that novaluron was the least impacted by rainfall. Overall, none of the products would be considered "rainfast" within the 16-hour window at which they were observed. Chemical analyses results correspond with water pick assay results. Novaluron was again the least impacted by rainfall because it provided one timing with results similar to the no simulated rainfall treatment.

Acknowledgements

I would like to thank Mississippi State University for this opportunity, my advisors Dr. Jeff Gore and Dr. Angus Catchot, my committee members, and Cotton Incorporated for funding and contributions to this research. I would also like to thank all full time and intermittent workers at Delta Research and Extension Center for all of their assistance and hard work.

Figures and Tables

Table 1. Percent mortality (SEM) for tarnished plant bug adults in laboratory bioassays conducted in 2020 evaluating the impact of rainfall on the efficacy of dicrotophos, thiamethoxam, sulfoxaflor, and acephate in cotton. Means within a column followed by the same letter are not significantly different according to Tukey's HSD (α=0.05).

	Percent Mortality (SEM)			
Time (hours after spray)	Dicrotophos	Thiamethoxam	Acephate	Sulfoxaflor
Untreated	6.7(2.6) C	8.0(1.4) B	6.1(2.7) BC	14.0(1.0) C
1	36.8(13.2) BC	16.3(1.7) B	3.8(2.4) C	11.4(1.2) C
2	37.5(5.9) BC	15.4(2.8) B	3.9(3.9) C	16.3(3.8) BC
4	33.3(2.6) BC	21.3(5.7) B	13.1(5.4) BC	39.0(9.3) B
8	50.7(9.9) B	18.6(5.6) B	7.3(4.2) BC	28.3(6.7) BC
16	43.1(9.4) BC	9.5(3.3) B	32.1(9.2) B	24.5(3.7) BC
NR	82.5 (0.91) A	91.3(1.4) A	98.7(1.3) A	92.5(1.4) A
F	9.5	43.27	79.8	47.28
d.f.	6, 21	6, 18	6, 21	6, 21
P>F	<0.01	<0.01	<0.01	<0.01

Table 2. Percent mortality (SEM) for tarnished plant bug immatures in laboratory bioassays conducted in 2020 evaluating the impact of rainfall on the efficacy of Novaluron in cotton. Means within a column followed by the same letter are not significantly different according to Tukey's HSD (α=0.05).

Percent Mortality (SEM)	
Time (hours after spray)	Novaluron
Untreated	4.9(2.0) C
1	20.0(4.0) BC
2	17.5(9.2) C
4	17.5(7.2) C
8	46.3(7.2) AB
NR	56.7(7.0) A
F	10.82
d.f.	5, 15
P>F	<0.01

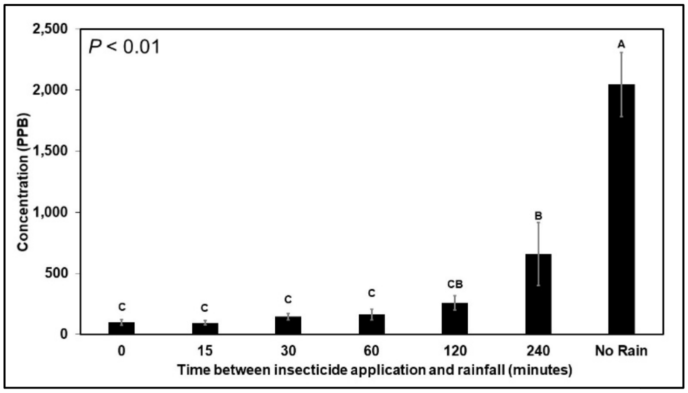

Figure 1. Concentration (PPB) of thiamethoxam after simulated rainfall event.

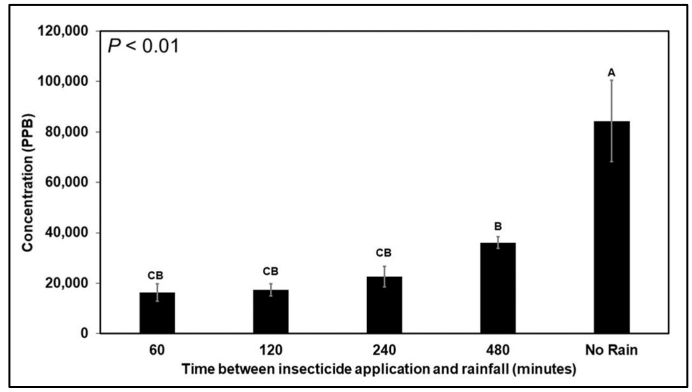

Figure 2. Concentration (PPB) of acephate after simulated rainfall event.

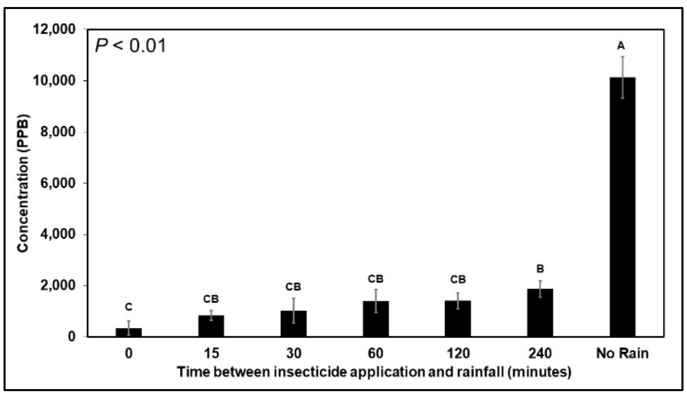

Figure 3. Concentration (PPB) of Sulfoxaflor after simulated rainfall event.

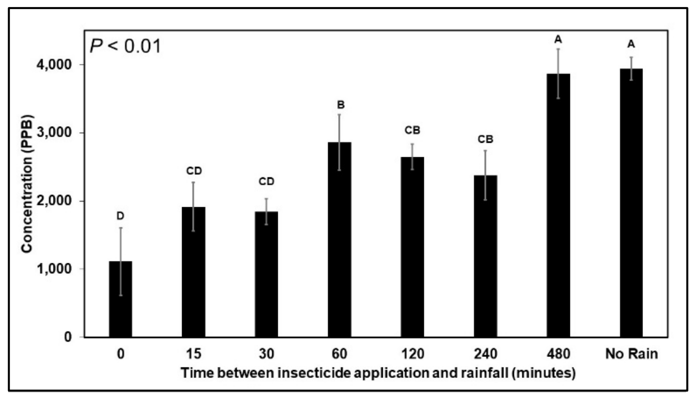

Figure 4. Concentration (PPB) of novaluron after simulated rainfall event.

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