STUDY OF THE EFFECTIVENESS OF BOLL WEEVIL CONTROL APPLYING DROPS OF A MIXTURE OF SEXPHEROMONE (GRANDLURE) AND CYPERMETHRIN THROUGH A PISTOL

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Abstract

To evaluate the field feasibility and agronomic efficiency of the mixture of the sexual pheromone (Grandlure) - 0.8%, mixed with cypermethrin - 6.4% (experimental compound Sirene BW), for the control of the boll weevil *(Anthonomus grandis,* Boh.), two tests were conducted at different locations in Paraná state (Brazil), during the 1994-95 cotton season. Application of Sirene BW was made with the help of a pistol, so that each pull on the trigger released a standard drop placed on the top leaves of a cotton plant. The drops had high viscosity, resembling a grease. The plots measured ca. 3.5-4.0 ha. On the central area of the plots, the drops were distributed 8 m apart from each other, and only 4 m apart on the borders (30 m around all the plot). The mixture was applied three times, with 10-14 day intervals. The first application was made 31-32 days after seed emergence and before square setting time. Plots with similar management practices were conducted for comparison purposes, where insecticides for boll weevil control were applied following official IPM recommendations. Evaluation of the treatments was made weekly, randomly choosing 12 locations measuring 400 m^2, assessing 25 squares/location and counting the number of bolls damaged either by feeding or oviposition. Results demonstrated that the mixture of pheromone and cypermethrin can efficiently control the pest up to 80 days after seed emergence. This treatment provided improved protection to the boll structure present on the lower half of the canopy, resulting in higher crop yield when compared to plots where the pest was exclusively controlled by insecticides. Application of Sirene BW near overwintering refugia sites delayed the spread of the boll weevil on the entire cotton field.

Introduction

The cotton complex represents one of the most important sectors of the Brazilian economy, considering its production, processing and final uses. The cotton area reached 3.5 million ha during the 1983/84 season, when the boll weevil was first detected, being 40% of the area cultivated with perennial varieties in northeast Brazil, where it represented the "cash crop" for the majority of the growers. After 12 years, the cultivated area declined to one third, but the global production was reduced only 17% (Ferreira, 1995). Economic and social problems were involved with the reduction of the cotton area, but the boll weevil played a major role in the move of the growers toward other opportunities, especially in the case of those who had not followed the appropriate technology recommendations.

Following the introduction of the boll weevil in northeastern Brazil, a reduction of up to 80% in the cotton area was observed, jointly with 75% yield reduction, and rising costs of pest control (Guimarães et al., 1986). It is estimated that 80% of the Brazilian cotton area is infested by the boll weevil, and overall Brazilian production corresponds to ca. 65% of the industry demand.

According to Cross (1973), the boll weevil is considered a major and wide-spread cotton pest in the United States. Losses due to the insect may reach $200 million (US), and statistics indicate that close to one third of all the insecticide used in the USA at that time was applied to control this pest, and constitutes almost the only means of protecting the crop. At first, calcium arsenate was used to control the boll weevil, followed by the discovery of the organochlorinated compounds. Intensive use of pesticides of this group, at higher rates, led to the development of resistance of the insect to these insecti-cides, and field control was begun with many organophosphorus insecticides (Parencia et al., 1983). More recently, a new group of synthetic pyrethroids (permethrin, cypermethrin, fenvalerate and deltamethrin) was developed which provided adequate efficiency in controlling moderate populations of the boll weevil (Hopkins et al., 1977; Santos, 1993; Ramiro et al., l 993).

Pheromones are chemicals released in the environment by one individual and detected by a second individual, provoking a specific reaction. Pheromones had been studied and developed, and had proven to be a potential component for the management of a comprehensive number of insect pests, all over the world The discovery of the utility of pheromones for survey, mass capture and even for the control of insect species, increased the evolution of their synthesis and formulation processes.

A review of earlier literature related to the sexual pheromone of the boll weevil was published by Hardee et al. (1972). The female response to the pheromone released by the male was confirmed in a laboratory test conducted by Keller (1964). Cross & Mitchell (1966) reported that male boll weevil feeding on cotton plants attracted females at distances of 9.1m or more. The adult male boll weevil produces an aggregating pheromone, to which both males and females are responsive (Cross & Hardee, 1968). Grandlure was the name given by Hardee et al. (1972) to the sexual pheromone isolated, identified and synthesized

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by Tumlinson et al (1969), which is composed of four main substances.

Pheromones are volatile substances, sensitive to oxidation or light degrada-tion, so their release in the field should be made considering protection of the volatiles against quick degradation (Vilela & Della Lucia, 1987). The same authors pointed out the need to control the rate of pheromone release against time.

To improve its commercial formulation, several studies were conducted. Bull et al (1973) found out that half life of the pheromone absorbed on a cigarette filter could be extended if protected by a 3.9 ml laboratory flask, acting as a physical barrier. McKibben et al. (1980) packed the cigarette filter impreg-nated with pheromone with a polyester film, which proved to be efficient in capturing boll weevils in the field. Presently, commercial formulations of Grandlure include laminated plastic plates and sheaves of microtubes.

Pheromone traps have proven their usefulness in capturing boll weevil adults, at the beginning and end of the plant cycle. Its efficiency is influenced by its shape, color, location, pheromone formulation, competition with male boll weevils present in surrounding sites, weather, plant phenology and physiological condition of the insects (Leggett, 1986).

Overwintering populations of the boll weevil can be adequately inferred through samplings made by the use of pheromone traps, detecting even populations so low, they would normally not be detected by other sampling methods (Merk et al., 1978). According to Write & Rummel (1978), cotton areas are first colonized by adult boll weevils overwintering in nearby areas. This migration seems to be a positive response to volatiles released by the plants during blooming, being the attraction improved through pheromone released by the first adults entering the field, and feeding on the squares. Studies made in the Campinas region (the county where the boll weevil was first recorded in Brazil) also proved the potential of pheromone traps for use in surveying the insect (Gabriel, 1984). Campanhola et al. (1988) captured adults of the insect during late fall and winter, proving activity of the boll weevil in the absence of cotton plants.

Sexual pheromones can be an alternative far integrated cotton pest management. The use of Gossyplure, the sexual pheromone of *Pectinophora gossypiella,* presented good control of this pest under Brazilian conditions (Brooks et al., 1981; Pappa et al., 1984). The sexual pheromone Grandlure has been studied as a bait also including a feeding attractant and malathion (McKibben, 1994; Santos, 1993).

Materials and Methods

Two tests were conducted in two counties of northern Paraná (Brazil), to evaluate feasibility and agronomic efficiency of the mixture of sexual pheromone and cypermethrin to control the cotton boll weevil. This experimental mixture will be marketed under the trade name of Sirene BW containing 0.8% of grandlure and 6.4% of cypermethrin,.based on a liquid UV absorber. The commercial formulation resembles a black grease, applied through a pistol that contains 24g of product, when fully charged, and regulated to deliver one drop (0.05-0.06 g) each time the trigger was pressed.

Test one was set up at Santo Antonio do Paraíso (Paraná-Brazil) county, with cotton planted Oct. 21, 1994, using cv. IAC-20, spaced 0.80m between rows. Total area measured 8 ha, split in two major plots, using the mixture of pheromone plus cypermethrin (Sirene BW) as treatment I and conventional insecticides as treatment II, for the control of the boll weevil. All other cultural practices were the same for both plots. Applications of the mixture were made over the entire area at 32, 40 and 52 days after seedling emergence, by releasing one drop of the mixture on leaves located on upper parts of cotton plant. On the central area of the plot, each drop was spaced 8m from the other, at the rate of one droplet/6.4 m^2, while this distance was reduced to 4m in the border area, consisting of 30m at each side of the plot. In this case, the rate of droplet application was one/3.2 m^2. Insecticide treatments on plot II were made following official IPM recommendations, and eight applications were needed to protect the crop. The insecticide application was made with the help of a bar sprayer equipped with D3-25 nozzles, at a pressure of 5.3 bar, delivering 150 l/ha. Nine surveys were made to evaluate results of the treatments, starting when plants in the plots were 46 days old, by randomly examining 12 sites each of 400 m^2, where 25 squares were examined and registering those damaged either by feeding or oviposition of the boll weevil. Details of treatments are shown on Table 1.

Test two was set up at Santa Cecília do Pavão (Paraná-Brazil), using a cotton area planted Nov. 7, 1994, using cv. IAC-20, with 0.80m of row spacing. Each major plot measured 3.5 ha, using the mixture of pheromone plus insecticide (Sirene BW) on plot A, and conventional insecticides on plot B, for the control of the boll weevil. On plot A it was necessary to apply the mixture three times, requiring an additional five insecticide applications at the end of the cycle for control of the pest complex. On plot B seven insecticide applications were needed, starting when plants were 64 days old. Pheromone and insecticide application, and also evaluations on efficacy were made exactly as described for test one.

Statistical analysis of both boll weevil damage and cotton yield was performed by comparing means of the treatments using the Student t-test for comparison of two means (Snedecor & Cochran, 1975), at p=0.05.

Results and Discussion

Results of test one are shown in Table 2. Evaluations made from 46 to 76 days after seedling emergence indicated a trend of better control of the boll weevil by the use of the mixture of pheromone and cypermethrin; even so statistical difference was found only on three out of six evaluation dates. During the period between 83 and 98 days, control of the boll weevil was equal for the mixture and the conventional insecticide application, and no statistical difference was found. On test two (Table 3), results indicated adequate control of the boll weevil either by the mixture or conventional insecticides up to 82 days after seedling emergence, being the damage of the insect equivalent, exception made for the count on day 68, where results for damage on plots receiving Sirene BW were statistically lower than those for the insecticide plot. The three last evaluations indicated a trend of finding more damage on the insecticide plot, although a statistical difference was found only on the evaluations made at 93 and 99 days.

As a side observation, for a better understanding of the pheromone behavior, surveys were made in the vicinity of the test area (Table 4). Results show a better performance of the mixture of pheromone and cypermethrin, as damage was consistently lower on cotton plants closer to the mixture plot.

Damage observed on the squares in the Sirene BW plot was predominantly caused by insect feeding, up to 90 day old plants, being not the case for the insecticide plot (data not shown). Also the application of the mixture close to the boll weevil refuge sites led to a reduction of the migration rate to the entire field area, thus reducing the boll weevil population in the studied area. These results were more clearly observed in test two, where the surrounding area was surveyed.

Tables 5 and 6 show yield data. Cotton production was higher in the plots receiving the mixture, on both locations, yielding 10.4-11.6 % more than the plots receiving insecticides for boll weevil control. No phytotoxic effects were observed.

Conclusions

1. The mixture of Glandlure plus cypermethrin (Sirene BW) applied 3 times at an interval of approximately two weeks showed adequate control of the boll weevil up to 80 days after seedling emergence, in both trials.

2. The increased yield observed on the plots receiving the mixture was due to an improved protection of the fruiting structures of the lower half of the cotton canopy.

3. Use of Sirene BW meets the requirements of cotton IPM, due to its selectivity to natural enemies of cotton pests, less amount of insecticide and the reduced impact over the environment and other non target organisms.

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Table 1. Products and rates used for boll weevil control. l 994/95.

Test one - Santo Antonio do Paraíso-PR, Brazil

Products	g a.i./ha
1. Grandure + Cypermethrin	0.65/1.30 + 5.1/10.2 (*)
2. Endosulfan	525
3. Methidathion	320
4. Betacyfluthrin	12.50
5. Prophenofos + Cypermethrin	400 + 40

(*): central area rate / border rate

Test two - Santa Cecília do Pavão-PR

Products	g a.i./ha
1. Grandure + Cypermethrin	0.65/1.30 + 5.1/10.2 (*)
2. Endosulfan	525
3. Betacyfluthrin	12.50
4. Prophenofos + Cypermethrin	400 + 40
5. Monocrotophos	240

(*): central area rate / border area rate

Table 2. Mean number of squares with boll weevil feeding and oviposition damage. Test one (Santo Antonio do Paraiso), 1994-95.

Treatment	Days after seedling emergence				
	46	51	55	60	69
1. Sirene BW	0.50	0.25	0.25	0.08	0.00
2. Insecticides	4,17	2.50	0.42	0.00	2.5
t-test	2.74*	2.92*	0.87	1.00	2.89*

Treatment	Days after seedling emergence				
	76	83	88	98	
1. Sirene BW	1.17	1.58	0.58	4.55	
2. Insecticides	1.25	0.92	0.67	4.25	
t-test	0.14	1.213	0.18	0.30	

* Means in the column are statistically different at p=0.05

Table 3. Mean number of squares with boll weevil feeding and oviposition damage. Test two (Santo Cecília do Pavão), 1994-95.

Treatment	Days after seedling emergence				
	37	45	54	60	68
1. Sirene BW	0.08	0.08	0.00	0.00	0.20
2. Insecticides	0.08	0.16	0.08	0.00	1.00
t-test	0.86	1.92	0.96	0.00	2.26*

Treatment	Days after seedling emergence				
	73	82	86	93	99
1. Sirene BW	0.08	0.17	1.42	1.43	0.75
2. Insecticides	0.92	0.33	0.83	2.32	3.00
t-test	1.83	0.73	0.73	2.92*	2.40*

* Means in the column are statistically different at p=0.05

Table 4. Mean number of squares with boll weevil feeding and oviposition damage, comparing areas in the vicinity of the treatment. Test two (Santo Cecília do Pavão), 1994-95.

Treatment	Days after seedling emergence				
	54	60	68	73	82
1. Sirene BW	0.00	0.00	0.17	0.08	0.17
2. Insecticides	0.00	2.00	1.50	4.00	13.50
t-test	0.00	3.10*	3.60*	3.63*	4.24*

Treatment	Days after seedling emergence		
	86	93	99
1. Sirene BW	1.42	1.33	0.75
2. Insecticides	13.50	15.25	11.00
t-test	3.41*	5.50*	3.95*

* Means in the column are statistically different at p=0.05

Table 5. Cotton yield expressed in kg/200 m2. Test one - Santo Antonio do Paraíso-PR, 1994-95.

	Treatment	
Plot	Sirene BW	Insecticides
1	48	47
2	59	48
3	60	49
4	57.6	52
5	65.5	46
6	51	50
7	56	48
8	49	55
9	50	-
Mean	55.12	49.37
t-test	2.47*	

* Means statistically different at p=0.05

Table 6. Cotton yield expressed in kg/200 m2. Test two - Santa Cecília do Pavão-PR, 1994-95.

	Treatment	
Plot	Sirene BW	Insecticides
1	50	50
2	49	44
3	52	46
4	53	45
5	50	48
6	-	43
Mean	50.8	46
t-test	3.56*	

* Means statistically different at p=0.05