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Survey and Efficacy of Certain Newer Insecticides against Sucking Insect Pests of Bt Cotton

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ABSTRACT

A survey conducted in 10 villages in Perambalur district showed that the incidence of sucking pests in Bt cotton had its changing scenario. The mean population of thrips in Bt cotton was high in the early vegetative stage with 10.84 per leaf . The mean population of aphids were high with a value of 7.17 per leaf when the crop was 30-35 days old. The population of leaf hoppers were low during the early stages and it increased when the crop was in maximum vegetative stage. The mean population of leafhopper was 4.32 per leaf and many fields showed the typical symptoms of hopper burn. The whitefly population was low during the early stages of the crop with the mean population of whitefly 2.81 per leaf and was very high during the maximum vegetative stages of the crop. The typical symptoms of upward curling and yellowing of the leaves was very high in Vallapuram area, when the crop was about 75-80 days after sowing. An evaluation of new molecules compatible with IPM shows the most significant treatment in controlling the leafhopper were imidacloprid@ 60 g a.i. ha^{-1} which has reduced the population to about 64% ; thiomethoxam @ 450 g a.i. ha^{-1} hreduced the whiteflies to 75% and acetamaprid45 g a.i. ha^{-1} reduced the aphids to 89 %,. The benefit cost ratio of the new molecule Imidacloprid was 1:2.5 followed by Thiomethoxan and Acetamaprid with 1:20 and 1:2.10 respectively besides being effective in checking the three sucking pests leaf hopper, white fly and aphids.

Key words: *Sucking Insect Pests, Bt cotton, Survey of insect pests, Efficacy of newer insecticides and cost benefit ratio*

INTRODUCTION

Cotton is an important fibre crop of global significance, which is, cultivated in tropical and sub-tropical regions of more than seventy countries the world over. The major producers of cotton are China, India, USA, Pakistan, Uzbekistan, Argentina, Australia, Greece, Brazil, Mexico, and Turkey. These countries contribute about 85% to the global cotton production. India has the largest average (10.33 m. ha) under cotton at global level and has the productivity of 486 kg Lint /ha and ranks second in production 295 lakh bales (5.02 million tonnes) after China during 2009-10.

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The Bt is a short form of ubiquitous soil bacterium *Bacillus thuringiensis*. This bacterium is gram positive and spore forming that forms parasporal crystals during stationary phase of its growth cycle. The synthesized crystalline proteins called 'endotoxins' are highly toxic to certain insects. They kill the insect by acting on the epithelium tissues of mid gut of caterpillars. These proteins often appear microscopically as distinctly shaped crystals and constitute about 20-30% of dry weight of sporulated cultures. These proteins are characterized by their insecticidal activityand are therefore grouped into four classes i.e. Lepidoptera-specific (Cry I), Lepidoptera and Diptera-specific (Cry II), Coleoptera-specific (Cry III) and Diptera-specific (Cry IV). Different strains of Bt produce more than 25 different but related insecticidal crystal proteins (ICPs). These are toxic to larvae of different insects including disease vectors and many agricultural pests. Cotton bollworms belong to the order Lepidoptera and therefore are sensitive to Bt Cry I and Cry II proteins, which are specific to them. Other beneficial insects are unaffected by these proteins. The gene bank data base of Bacillus Genetic Stock Centre (BCSC) have given a list of Cry(Crystal), Cyt (Cytolytic) and Vip genes either synthetic or modified versions from *B. thuringiensis* about 22 classes of Cry including 126 Cry genes have been registered along witha Crt gene and 3 Vip (Vegetative insecticidal protein) genes. But popularly and effectively utilized are Cry 1 Ac, Cry 1 Ab in different crops.

The decision of the Genetic Engineering Approval committee (GEAC) of Government of India clearing the release of Bt cotton for commercial cultivation during 2002-2003 crop season, is considered as one of the major milestones in the history of cotton improvement in India.

Cotton (*Gossypium hirsutum* Linn.), an important commercial / fibre crop in India plays a key role in national economy with an export worth of Rs.38, 000 crores[2]. In India, it is grown under varying climatic and soil conditions in an area of 85.6 lakh ha, with a production of 223 lakh bales. An area of 1.10 lakh ha has been recorded under Bt cotton cultivation[1].

In 2010, the adoption of Bt cotton in India soared to a record 9.4 million hectares, equivalent to 86% of the record 11 million hectare cotton crop planted in the country. On average, Bt adopting farmers realize pesticide reductions of about 40%, and yield advantages of 30-40%.

Tamil Nadu accounts for 1.60 lakh ha producing 5.50 lakh bales with a productivity of 584 kg lint ha^{-1} as against the national average of 294 kg ha^{-1} [2]. In India, 162 species of insect pests attack different stages of cotton. Of these, about a dozenare major and half of them are key production constraints necessitating management interventions in the crop ecosystem. The sucking pest complex comprising of aphids, jassids, thrips and whitefly are widespread and fairly serious. However, their damage can be efficiently contained by the existing practices of cultural, chemical, biological and host resistance means.The bollworms are most important tissue feeders and highly damaging. Three types of bollworms viz. American bollworm (*Helicoverpa armigera*), Pink bollworm (*Pectionphora gossypiella*) and Spotted bollworm (*Earias vitella*), normally referred as bollworm complex are by far the most damaging and loss inducing pests of cotton. Amongst them, *Helicoverpa* emerged as a key pest all over the country causing as high as 80% losses in cotton.

Cotton growers in India depend heavily on synthetic pesticides to combat sucking pests. At least 2-3 sprays are directed against sucking pests. Due to continuous and indiscriminate use of synthetic insecticides, there is resistance and hence the efficacy has become less reliable. To overcome this problem discovery of novel substances with different biochemical targets are needed. Novel molecules are effective at low doses and have less exposure in the environment.

MATERIALS AND METHODS

Method of assessment of pest population

Two farmers' field was surveyed from each village, giving a total of 20 fields as whole. The crop was at the stage of 35,45 and 60 DAS during that period and the sucking pest infestation was crossing the ETL. The 10 villages surveyed were Kurumbalur, Eechampatti, Melapuliyur, Navalur, Palayam, Mettankadu, Melankadu, Perali, Sithali and Kunnam. Five plants were randomly selected from each quadrate and tagged for recording the various observations. Population of sucking pests *viz*; aphid (*Aphis gossypii* G.), leafhopper (*Amrasca bigutulla* Ishida) and whitefly (*Bemisia tabaci* Gen.) was recorded from 3 leaves (top, middle and bottom) of each tagged plant. Thus in all 15 leaves were examined and based on this mean population of each sucking pest per 3 leaves was worked out.

Evaluation of the newer molecules compatible with IPM practices in Bt cotton.

An experiment was conducted in Vallapuram village near Valikandapuram, Perambalur district in randomized block design (RBD) with 4+1 treatments and replicated five times to evaluate the efficacy of the sucking pests in cotton. The treatments were imposed when the pests crossed ETL at the respective doses and control plots were given water spray with a pneumatic knapsack sprayer using 500 litres of spray fluid per hectare. The insecticides used in the present investigation and their dosages were as follows.

Treatments	Details of Treatments	A.i. g /ha
T_1	Acetamprid	45
T_2	Imidacloprid	60
T_3	Diafenthiuron	75
T_4	Thiomethoxam	450
T_5	Control.	------

The sucking pests *viz*., whitefly, *B. tabaci*, aphid, *A. gossypii* and thrips, *T. tabaci* was recorded on three leaves one each at top, middle and bottom portions from 10 randomly tagged plants per plot prior to spraying and 3, 5 and 15 days after spray. The data collected on the pre and post assessments were subjected to statistical analysis as per the manual "Modern Trends in Pest Management".

Date of assessment: 11-11-2014 and 12-11-2014

Date of spraying: 25-11-2014

Date of post-treatment assessment: 26-11-2014, 28-11-2014 and 2-12-2014

The third objective is to work out the cost of each molecule tested on Bt cotton crop and the cost incurred were worked. Finally the cost benefit of each molecule was worked out apart from their efficacy.

RESULT AND DISCUSSION

Survey of pest in Bt cotton

The results of the survey from the 10 villages of Perambalur district gave the current pest status of the Bt cotton. Also, the pest intensity of the sucking pests in the different crop growth stages showed the following:

The crop at an early stage, about 35 days after sowing and attained a height of 45-55 cm above the ground with a few sympodial branches. The pest population of leafhoppers, whiteflies, aphids and thrips were recorded and the average value of the pest population was studied. As the crop was at an early stage, the populations of thrips were found to be high when compared to the other sucking pests in cotton. The populations of whiteflies and leafhoppers were found to be less when compared to the same crop at the late or medium stage of vegetative growth. The thrips can be observed on the underside of the leaves residing in large numbers, which caused rusty appearance and curling of leaves. The aphid population was also found to be medium to high in various fields and the typical symptoms like the presence of sooty mould and downward curling were observed in the fields. A mean value of 10.84 per leaf for thrips and 7.17 per leaf for aphids were obtained from the survey, while a mean value

of 4.32 per leaf for leafhoppers and 2.81 per leaf for whiteflies were observed from the Bt cotton field during the early stage of the crop vide table -1**.** The pest status changed as the crop grew and in the early vegetative stages, the populations of leafhoppers and whiteflies were high which produced the visible symptom of hopper burn and upward curling of the leaves, while the whitefly infestation was severe in late stages of vegetative period.

Pest status and their intensity in Bt cotton

The pest status in the Bt cotton crop for the four pests assessed showed that aphid was moderate in the early and maximum vegetative stage. Leafhoppers were low in the early vegetative stage and high in the maximum vegetative and reproductive stages. Whitefly was high in the maximum vegetative stage and moderate in the reproductive stages. With regard to thrips, it was high in the early and maximum vegetative stages. The pest intensity with their occurrence in the Bt cotton crop as assessed in the 10 villages assessed is appended vide table 2

Effect of newer molecules on leaf hopper

The four new molecules were evaluated in a field trial in Bt cotton at Vallapuram village resulted the significance of the four insecticides were as follows:

Among the four insecticide treatments, imidacloprid was the most significant treatment in checking the leafhopper population. It brought the population to ETL on the spray. All the other insecticides were effective in checking the leaf hoppers than the untreated control.. The next in line was thiomethoxam with 1.5/leaf vide table 3**.** The study is in accordance to the studies of Preetha[5] had stated on Imidacloprid 70 WS at 35 g a.i. ha^{-1} kept the population of sucking pest complex below economic threshold level in cotton. Further by Preetha[5] who has also on reported that imidacloprid at 25 g a.i. ha^{-1} was effective in checking the population of leafhoppers up to 25 days after treatment . These is akin to our study made in the farmers field. The percent reduction of the jassids in imidachlopridi is appended where the reduction was 64.32. % .

Effect of newer molecules on whitefly

All the new molecules tested were found to be effective in checking the white fly population. The molecule thiomethoxam was most significant with a mean population of 2.14 per leaf compared to control with 8.58 per leaf. It was followed by 2.48 per leaf, which was imidacloprid. The next treatment which was on par were acetamaprid and diafenthiuron which were 2.63 per leaf vide tabe 4. These study and the result is in line with the studies conducted by Patil[4] and Jayaprabhavathi[3]. However, our studies indicated the effectiveness of thiomethoxam to check the whiteflies.

Effect of newer molecules on aphids

The results of the treatment imposed on Bt cotton for the control of aphids showed that the effectiveness in reducing the population than the untreated plots. Among the treatments, acetamaprid 70WP was most significant with a mean population of 1.78 per leaf compared to the control with 16.25 per leaf. This was followed by thiomethoxam (2.06 per leaf), imidacloprid (2.11 per leaf) and diafenthiuron (2.19 per leaf). All these were on par vide table **5**. Also, the calculated value of reduction in population compared with the control in the aphids was 89.04%. This significance is in line with the study of Subramaniam and Natarajan[6], who has reported this in their study with acetamaprid @ 10g ai per ha. The percent reduction of aphids in acetamaprid was 75 %.

The benefit cost ratio of the newer molecules

The cost of the new molecules tested with their yield was compared for the cost effectiveness to that of the control plot which was not sprayed. All the four insecticides acetamaprid, imidacloprid, thiomethoxam and diafenthiuron proved to be cost effective in checking all the sucking pests. The benefit cost worked were 1;2.5 for the insecticide imidachloprid followed by other molecules which were around 1: 20 vide table-6. The most cost effective molecule tested as per our study was imdiachloprid.

Table1: Mean pest population in Bt cotton in 10 villages of Perambalur district

Sl.No	Name of the Villages	*Mean number of sucking pests/ leaf			
		Aphids	Leafhoppers	Whiteflies	Thrips
1	Kurumbalur	9.5	3.5	2.3	12.4
2	Eechampatti	8.5	5.1	3.2	11.25
3	Melapuliyur	7.75	4.4	2.25	11.1
4	Navalur	6.65	5.75	3.3	11.6
5	Palayam	6.8	3.1	2.1	10
6	Mettankadu	4.4	4.6	3.7	9.1
7	Melankadu	6.7	6.5	2.2	9.3
8	Perali	6.9	3.5	3.3	12
9	Sithali	7	3.8	3.1	10
10	Kunnam	7.9	3	2.7	11.7
	Mean*	7.17	4.32	2.81	10.84

*Mean pest population assessed as per the methodology stated in Directorate of Agricultural publication, 1983.

Table 2: Pest status in different crop growth stages of Bt cotton

Crop growth stages	Pest and their intensity			
	Aphids	Leafhoppers	Whiteflies	Thrips
Early vegetative	**M**	**L**	**N**	**H**
Medium vegetative	**M**	**H**	**H**	**H**
Reproductive	**M**	**H**	**M**	**N**
Maturity	**N**	**N**	**N**	**N**

+ H- High ;M- Moderate L- Low; N- Nil

Table 3: Efficacy of newer molecules against leafhoppers

Treatment	Mean population of leafhopper/ leaf			Cumulative mean	Mean percentage over the control (%)
	1 DAS	7 DAS	15 DAS		
1. Acetamaprid	0.58 (0.76)[b]	2.18 (1.48)[e]	3.26 (1.81)[c]	2.006	28.86
2. Imidaclorpid	0.44 (0.66)[a]	1.16 (1.08)[a]	1.42 (1.19)[a]	1.006	64.32
3. Difenthiuron	1.44 (1.20)[c]	1.7 (1.30)[c]	2.2 (1.48)[b]	1.78	36.87
4. Thiometoxam	0.68 (0.82)[b]	1.52 (1.23)[b]	2.3 (1.52)[b]	1.5	
5. Control	1.84 (1.36)[d]	3.24 (1.80)[d]	3.4 (1.84)[d]	2.82	
SEd	0.0456	0.0294	0.0190		
CD (0.5)*	0.0966	0.0624	0.0404		
CD (0.1)**	0.1331	0.0860	0.0556		

Mean of replications; DAS – Days after spraying ' or **' significant level at 5% and 1%.

Table 4: Efficacy of newer molecules against whiteflies

Treatment	Mean population of whiteflies/ leaf			Cumulative mean	Average reduction percentage (%)
	1 DAS	7 DAS	15 DAS		
1. Acetamaprid	1.82 (1.35)[a]	3.12 (1.77)[c]	2.96 (1.72)[c]	2.63	69.34
2. Imidaclorpid	1.8 (1.34)[a]	2.82 (1.68)[b]	2.84 (1.69)[b]	2.48	71.09
3. Difenthiuron	1.78 (1.33)[a]	3 (1.73)[b,c]	3.12 (1.77)[d]	2.63	69.34
4. Thiometoxam	1.66 (1.29)[a]	2.28 (1.51)[a]	2.5 (1.58)[a]	2.14	75.05
5. Control	8.16 (2.86)[b]	8.56 (2.93)[d]	9.04 (3.01)[e]	8.58	100
SEd	0.0300	0.0321	0.0157		
CD (0.5)*	0.0637	0.0680	0.0333		
CD (0.1)**	0.0877	0.0937	0.0459		

Mean of replications; DAS – Days after spraying ' or **' significant level at 5% and 1%.

Table 5: Efficacy of newer molecules against aphids

Treatment	Mean population of Aphids/ leaf			Cumulative population	Average pest reduction (%)
	1 DAS	7 DAS	15 DAS		
1. Acetamaprid	1.76 (1.33)[a]	1.94 (1.39)[a]	1.64 (1.28)[a]	1.78	89.04
2. Imidaclorpid	2.22 (1.49)[c]	2.24 (1.50)[b]	1.88 (1.37)[b]	2.11	87.01
3. Difenthiuron	1.98 (1.41)[b]	2.52 (1.59)[c]	2.08 (1.44)[c]	2.19	86.52
4. Thiometoxam	1.84 (1.36)[a,b]	2.08 (1.44)[a]	2.26 (1.50)[d]	2.06	87.32
5. Control	15.76 (3.97)[d]	16.42 (4.05)[d]	16.58 (4.07)[e]	16.25	100
SEd	0.0241	0.0245	0.0234		
CD (0.5)*	0.0511	0.0520	0.0496		
CD (0.1)**	0.0704	0.0717	0.0684		

Mean of replications; DAS – Days after spraying;' or **' significant level at 5% and 1%.

Table 6: Cost Benefit Ratio of certain newer insecticides

Treatment	Yield Kg/kappas	Cost of Insecticide tested Rs.	Additional yield obtained than control Rs.	Added profit to that of control Rs.	Benefit cost Ratio
Imidachloprid	2550	3000	550	7700	1:2.5
Thiomethoxam	2450	3000	450	6300	1:2.1
Acetamaprid	2500	3500	500	7000	1:2.0
Difenthurion	2600	4000	600	7800	1:1.95
Control*	2000	-	-	-	-

*Un-treated plot yield- calculated difference in yield worked out for cost benefit

CONCLUSION

The survey done in 10 villages of Perambalur district showed that the incidence of sucking pests in Bt cotton has its changing scenario. The population of thrips in Bt cotton was high in the initial stage and the downward curling with silvery appearance of the leaves were observed. The mean value of 10.84 per leaf was observed during the survey, which means that the population of thrips is severe during the early stages of 30-35 days after sowing.

The mean population of aphids were also observed to be high with a value of 7.17 per leaf when the crop was 30-35 days old. The population of aphids, the population decreased significantly as the crop grew and the population was low during the maturity stages.

The population of leafhopper was also less during the early stages and it increased when the crop grew. The mean population of leafhopper was 4.32per leaf and many fields showed the typical symptoms of hopper burn.

The population of whitefly was low during the early stages of the crop and the mean population of whitefly was 2.81 per leaf . The whitefly infestation was very high during the late stages of the crop. The typical symptoms of upward curling and yellowing of the leaves was very high in Vallapuram area, when the crop was about 75-80 days after sowing. Evaluation of new molecules compatible with IPM shows the most significant treatment in controlling the leafhopper were imidacloprid@ 60 g a.i. ha^{-1} which has reduced the population to about 64% ; thiomethoxam@ 450 g a.i. ha^{-1} has reduced the whiteflies to 75%and acetamaprid45 g a.i. ha^{-1} which reduced the aphids to 89 %,. The benefit cost ratio of the new molecule Imidacloprid was 1:2.5 Thiomethoxan and Acetamapridwith 1:20 and 1:2.10 respectively.

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