Insecticide induced abundance of *Helicoverpa armigera* Hüb. and upsurge of *Aphis gossypii* Glov. in cotton

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ABSTRACT

Investigations carried out to assess the influence/ effectiveness of newer insecticides including certain new synthetic pyrethroids, revealed that the synthetic pyrethroids viz., alphacypermethrin, betacyfluthrin, zetamethrin and cypermethrin recorded significantly higher population of cotton bollworm. Helicoverpa armigera *Hübner, 15.3 to 18.2, 11.6 to 15 and 11.4 to 13 per five plants as against 7, 7.7 and 9.8 per five plants in control during 1999-2000, 2000-01 and 2001-02 respectively. They also recorded significantly higher fruiting bodies damage of 42.5 to 44.4, 19.1 to 27 and 42.5 to 54.1 percent as against 13.9, 13.7 and 54.7 percent in the control. The higher incidence and damage due to bollworms in these treatments resulted in significantly lower seed cotton yields, which were on par with untreated controls. Besides, they also recorded significantly higher population of cotton aphid,* Aphis gossypii *Glover, 360 to 460 per three leaves as against nine to 87 per three leaves in control. The enhanced level of reducing sugars by two fold and 38 percent lower level of phenolic substances as compared to control in the leaves of treated plants with these insecticides were attributed for the upsurge of* A. gossypii *and abundant occurrence of* H. armigera. *In contrast to this, treatments with spinosad, F 6028, indoxacarb and bifenthrin were significantly superior in controlling larval populations of* H. armigera, *recording low fruiting bodies damage and increasing the seed cotton yield.*

Introduction

Cotton is the most important cash crop of India. Many problems have arisen due to inappropriate and excessive use of insecticides in the cotton ecosystem. In the past, applications of DDT rapidly led to the outbreak of red spider mite in many areas and control of boll weevil was followed by severe infestation of *Heliothis zea* and *Helicoverpa virescens* in USA (Mathews, 1994). Indiscriminate use of insecticides has been one of the primary factors responsible for severe infestations of whiteflies and aphids causing inferior quality of lint due to honeydew and sooty moulds. In several cases, repeated application of insecticides has led to pest populations becoming so resistant that farmers were no longer able to grow the crop profitably in Mexico (Adkisson, 1971), Australia (Basinski and Wood, 1987) and India (Armes *et al*., 1994). Reported here are the observations on the occurrence of cotton bollworm, *Helicoverpa armigera* Hübner and upsurge of the cotton aphid, *Aphis gossypii* Glover after the application of insecticides during three years of cropping in Coimbatore, India.

Experimental procedure

Three field experiments were conducted during 1999-2002 in the winter cotton season (August-February) in a randomized block design with three replications (Tables 1, 2 and 3). The popular commercial cultivar LRA 5166 was used in the experiments. All the agronomic practices were followed as recommended for the variety. In all the experiments the early season sucking pests were controlled by spraying either methyl-o-demeton @ 500-600 ml/ha or imidacloprid @ 100 ml/ha. During 1999-2000, six rounds of treatment sprays of indoxacarb 15 SC at 60,75 g a.i./ha; spinosad 48 SC at 50,75 g a.i./ha; alphacypermethrin 5 EC at 12.5, 18 g a.i./ha and endosulfan 35 EC at 875 g a.i./ha were given at two weeks interval, commencing the first round on 66 days after sowing. During 2000-2001 five rounds of treatment sprays of spinosad 48 SC at 50 g a.i./ha; indoxacarb 15 SC at 75 g a.i./ha; F 6028 20 SC at 100 and 150 g a.i./ha; bifenthrin 10 EC at 60 and 80 g a.i./ha; betacyfluthrin 2.5 EC 18 g a.i./ha and zetamethrin 10 EW at 40 and 60 g a.i./ha were given on 78, 85, 98, 112 and 127 days after sowing (DAS). During 2001-02 four rounds of treatment sprays of chlorpyriphos methyl 45 SC at 750 and 1000 g a.i./ha; F 6028 20 SC at 100 and 150 g a.i./ha; bifenthrin 10 EC at 60 and 80 g a.i./ha and cypermethrin 5 DF at 60 and 70 g a.i./ha were given on 88, 105, 115, 119 and 122 DAS. High volume sprayer (hand operated knapsack sprayer) with 750 liters/ha volume of water was used in all the three experiments. Controls were left untreated. Larval population of *Helicoverpa* bollworm and fruiting bodies damage were assessed from ten plants taken at random at periodical intervals. Yield data were gathered and all the data were subjected to statistical scrutiny. Plant sample powder was analyzed for total phenols following the method of Bray and Thorpe (1954) and for reducing sugars as per the method of Nelson (1954).

Results and Discussion

Experiment I (1999-2000)

The larval population of the dominant bollworm, *H. armigera* was significantly lower, 1 to 3.3 per 10 plants in spinosad treatments and in indoxacarb at higher dosage treatment (75 g/ha), which had 3 to 4.7 larvae. However, alphacypermethrin and betacyfluthrin treatments recorded significantly higher population of 38 to 44 and 23 to 29 larvae per 10 plants respectively on 90 and 100 DAS as against 12 and 9 per 10 plants in control. The fruiting bodies damage was also significantly low, 1 to 2 percent in the former treatments while it was ranging from 42.5 to 44.2 percent in the later treatments and 13.9 percent in control. With regard to seed cotton yield, it was significantly higher in the former treatments, 1800 to 2360 kg/ha while it was significantly lower, ranging from 640 to 950 kg/ha in the later treatments and 710 kg/ha in the control (Table 1).

Experiment II (2000-01)

The larval incidence of *H. armigera* was significantly lower in treatments *viz.*, F 6028, indoxacarb, bifenthrin and spinosad ranging from 0.3 to 2.3 per 5 plants while it was significantly higher in treatments of betacyfluthrin and zetamethrin ranging from 11.6 to 15 per five plants as against 7.7 per five plants in control. The same trend of results was observed in fruiting bodies damage also. The effective treatments *viz.*, F 6028, indoxacarb, bifenthrin and spinosad registered significantly less damage of 0.9 to 2.9 percent while the ineffective treatments *viz.*, betacyfluthrin and zetamethrin registered significantly higher damage of 19.1 to 27 percent as against 13.7 percent in control. The effective treatments recorded significantly higher yield of 1670 to 2040 kg/ha while the ineffective treatments recorded 1050 to 1270 kg/ha as against 1180 kg/ha in control (Table 2). The population of aphids was significantly low in the effective treatments and were on par with control while it was significantly higher in the ineffective treatments recording 640 to 900 aphids per five leaves as against 130 per five leaves in the control.

Experiment III (2001-02)

The population of *H. armigera* was lower in treatments of F 6028 and bifenthrin through out the observation period and the mean for five observations on 101, 106, 116,120 and 123 DAS ranged from 2.5 to 5.4 per 5 plants while it was 11.4 to 13 per five plants in cypermethrin and 9.8 per five plants in control. The fruiting bodies damage was significantly less in the effective treatments (F 6028 and bifenthrin) wherein it ranged from 3.9 to 11.2 percent while it was 42.5 to 54.1 percent in cypermethrin and 54.7 percent in control. The seed cotton yield was significantly higher in the effective treatments ranging from 1085 to 1901 kg/ha while it was 470 to 514 kg/ha in cypermethrin and 396 kg/ha in the control (Table 3). The population of aphids was significantly high in cypermethrin treatments wherein it ranged from 370 to 460 per three leaves as against 87 per three leaves in control.

Estimation of biochemical substances *viz.*, reducing sugars and total phenol revealed that pyrethroid (fenvalerate-cypermethrin-fenvalerate) had nearly two fold higher level of reducing sugars and 38 percent lowered level of total phenols as compared to control.

In the present study, during the year 1999-2000, alphacypermethrin, and betacyfluthrin did not reduce the larval population of *H. armigera* on both the observations *viz.*, 90 and 100 DAS. On the other hand, they recorded a higher larval population of 31 to 36 per 10 plants as against 11 in control (Figure 1). This led to significantly higher level of fruiting bodies damage (42.5 to 44.2 %) and significantly low yield (640 to 950 kg/ha). Larval reduction of 64 to 89 percent was observed in the effective treatments *viz.*, indoxacarb and spinosad, which were significantly superior to all other chemical treatments and control. Further, they also recorded significantly higher seed cotton yield of 1800 to 2360 q/ha as against 640 to 1130 q/ha in other treatments. The effectiveness of these insecticides has also been observed by Vadodaria *et al.*, (2001) and Dhawan and Simwat (2000).

The results from the second year, 2000-01 also showed that the pyrethroid treatments *viz.*, betacyfluthrin and zetamethrin registered 52 to 96 percent higher larval population of *H. armigera* (11.7 to 5.0/5 plants) over the control (7.7/5 plants). Further, these treatments also recorded significantly higher population of aphids ranging from 64 to 695 per five leaves as against 130 in control (Figure 2). F 6028, bifenthrin, indoxacarb and spinosad had significantly lower larvae of *H. armigera* (0.3-3/5 plants) as compared to the control (7.7/5 plants) and recorded significantly higher seed cotton yield of 1870 to 2090 q/ha as against control (1180 q/ha).

In the third year, the synthetic pyrethroid treatment- cypermethrin 5DF also recorded 15 to 30 percent higher larval population of *H. armigera* (11.4–13/5 plants) as against 9.8 in control and proved to be ineffective. This led to higher fruiting bodies damage and poor seed cotton yield. F 6028 was consistently superior to other insecticides (chlorpyriphos methyl and cypermethrin 5DF) and control in respect of recording significantly lower larval population of *H. armigera*, low fruiting bodies damage and higher seed cotton yield.

The mechanism of altered physiology of cotton plants as affected by synthetic pyrethroids including cypermethrin in respect of recording higher larval population of *H. armigera* during the last three years needs to be investigated in detail. However, the preliminary investigations on this aspect revealed that lowered levels of phenolic substances (38%) and the enhanced availability of reducing sugars by two fold observed in synthetic pyrethroid treated plants, as observed in our studies, offer probable reason for this phenomenon. In the present investigations, the predominant sucking pest was *Aphis gossypii* and almost all the pyrethroid treatments *viz.*, alphacypermethrin, betacyfluthrin, zetamethirn and cypermethrin registered significantly higher populations. This led to development of sooty mould on the leaves, which later contaminated the seed cotton. The most probable reason for the upsurge of *A. gossypii* in these pyrethroid treatments may be the enhanced level of reducing sugars and the lowered level of phenolic substances in the leaves of treated plants as observed in our studies (Figure 3).

Conclusion

As the existing chemicals are becoming obsolete, newer insecticides are being evaluated for their effectiveness in cotton. An IPM program, in which timing of insecticide application is related to crop and pest monitoring, is being extensively followed in India in recent years. Many insect pests and mites infest cotton fields and adversely affect the yield and quality of seed cotton. Farmers usually rely on chemicals to control these pests. However, these chemicals can also cause destruction of parasitoids and predators and lead to the risk of resistance development to an insecticide. For avoiding the negative effect, extra care is required in introducing newer molecules of chemical insecticides to small-scale farmers who are mostly unfamiliar with timely and improved method of application of insecticides. In this context, the present investigations demonstrated that the synthetic pyrethroids alphacypermethrin, betacyfluthrin, zetamethrin and cypermethrin could influence the abundance of the cotton bollworm *H. armigera* and upsurge of the cotton aphid *A. gossypii*.

Biochemical aspects of cotton plant metabolism due to influence of insecticide application resulted in various responses in case of phenols and gossypol. The effect of insecticides (fenvalerate and methyl-o-demeton) on the level of phenol and ortho-di-hydroxy phenol showed a very short decline after 24 hours of application to an extent of 38 percent whereas there was an increase in reducing sugars concentration (Chakravarty, 1999; Gopalakrishanan *et al*., 2001). Moderate rise in the activity of Nitrate Reductase (NR) and soluble protein after two sprays with methyl-o-demeton during squaring and peak flowering has also been reported. However, repeated application of endosulfan and monocrotophos was found to lower NRase activity to an extent of 10 to 15 percent. Thus, variable responses were seen in the regard to insecticide application on cotton.

In the present study, increased levels of reducing sugars and lowered levels of phenolics in synthetic pyrethroids, has probably resulted in higher biological responses viz., higher infestation by *H. armigera* and upsurge of *A. gossypii*. However, this needs a thorough and in depth confirmative study to throw a light on the enhanced level of pest appearance after application of certain groups of insecticides like pyrethroids in cotton. Thus, it cautions everybody who is in the field of cotton plant protection to be very careful in selecting the proper insecticides for the control/ management of these pests.

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Table 1. *Reaction of newer insecticides on* H. armigera *and* A. gossypii *in cotton (1999/2000).*

Treatment	Dose (g a.i./ha)	*Helicoverpa* larvae/10 plants 90 DAS[1] 10 DATS[2]	100 DAS 7 DATS3	FBD %	Seed cotton yield (kg/ha)
Indoxacarb 15 SC	60	8.0	6.0	7.8	1796
Indoxacarb 15 SC	75	3.0	4.7	2.0	1854
Spinosad 48 SC	50	3.3	2.0	1.8	1881
Spinosad 48 SC	75	1.3	1.0	1.0	2358
Alphacypermethrin 5EC Farsa	25	43.3	29.3	43.4	635
Alphacypermethrin 5EC Farsa	30	37.7	26.7	42.5	725
Betacyfluthrin 2.5 EC	12.5	44.0	28.3	44.2	905
Betacyfluthrin 2.5 EC	18	38.3	22.7	43.5	950
Endosulfan 35 EC	875	22.3	14.3	18.6	1125
Control		12.3	9.3	13.9	710
CD (P=0.05)		0.80	0.71	6.81	293

[1]DATS 2, 3- Days after treatment spray

[2]DAS- Days after sowing

Table 2. *Newer insecticides on the abundance of* H. armigera *and upsurge of* A. gossypii *in cotton (2000/01).*

Treatments	Dose (g ai/ha)	*H .armigera* larval population/5 plants 98 DAS*	Fruiting bodies damage (%) 98 DAS	Aphid/5 leaves 123 DAS	Seed cotton yield (kg/ha)
Spinosad 48 SC	50	2.33 (1.68)	2.63 (9.31)	120 (1.93)	2086
Indoxacarb 14.5 SC	75	1.00 (1.17)	2.17 (7.86)	75 (1.87)	1669
F 6028 20 SC	100	0.33 (0.88)	1.33 (6.36)	347 (2.42)	1866
F 6028 20 SC	150	0.33 (0.88)	0.90 (5.40)	255 (2.27)	1930
Bifenthrin 10 EC	60	1.33 (1.27)	2.93 (9.79)	318 (2.41)	1996
Bifenthrin 10 EC	80	7.67 (2.84)	2.90 (9.30)	227 (2.33)	2037
Betacyfluthrin 2.5 EC	18	15.00 (3.80)	26.97 (30.31)	695 (2.83)	1273
Zetamethrin 10 EW	40	11.67 (3.45)	25.30 (29.97)	900 (2.95)	1048
Zetamethrin 10 EW	60	12.67 (3.63)	19.07 (25.77)	640 (2.80)	1237
Control			13.67 (21.60)	130 (2.00)	1184
CD (P=0.05)		0.93	7.77	0.52	288

*DAS- Days after sowing

Table 3. *Effect of newer insecticides on the abundance of* H. armigera *and upsurge of* A. gossypii *in cotton (2001/02).*

Treatment	Dose (g ai//ha)	H. armigera larvae / 5 plants: 101 DAS[1] 13DATS1[2]	106 DAS 5DATS2	116 DAS 15DATS2	120 DAS 4DATS3	123 DAS 7DATS3	[3]FBD (%)	Aphid / 3 leaves 125 DAS	Seed cotton yield (kg/ha)
Chlorpyriphos methyl 45 SC	750	9.7 (3.05)	8.0 (2.81)	7.3 (2.84)	7.0 (2.64)	3.7 (1.86)	27.9 (31.7)	16.4 (4.13)	573
Chlorpyriphos methyl 45 SC	1000	9.3 (3.50)	7.3 (2.70)	9.6 (3.08)	4.6 (2.15)	5.7 (2.38)	19.5 (26.1)	13.0 (3.64)	952
F 6028 20 SC	100	6.7 (2.47)	4.6 (2.10)	7.6 (2.67)	3.3 (2.06)	1.7 (1.27)	11.2 (19.5)	164.6 (12.86)	1085
F 6028 20 SC	150	2.7 (1.61)	2.6 (1.58)	3.3 (1.76)	2.3 (1.47)	1.7 (1.27)	3.9 (10.9)	133.4 (11.52)	1496
Bifenthrin 10 EC	60	5.0 (2.37)	5.6 (2.36)	7.6 (2.76)	3.6 (2.19)	1.3 (1.41)	4.3 (11.9)	200.2 (14.16)	1901
Bifenthrin 10 EC	80	4.3 (2.07)	5.0 (2.21)	7.3 (2.70)	6.0 (2.41)	4.3 (2.08)	8.6 (17.0)	220.0 (14.86)	1748
Cypermethrin 5DF	60	12.0 (3.62)	16.3 (4.03)	17.6 (4.19)	11.0 (3.31)	8.3 (2.92)	42.5 (40.5)	459.6 (21.51)	514
Cypermethrin 5DF	70	11.0 (3.29)	14.3 (3.77)	11.6 (3.40)	11.0 (3.31)	9.3 (3.04)	54.1 (47.3)	370.6 (19.27)	470
Control		10.3 (3.19)	14.6 (3.82)	10.0 (3.15)	8.0 (2.82)	6.0 (2.39)	54.7 (47.8)	87 (9.36)	396
C.D. (P=0.05)		0.89	0.69	0.75	0.64	0.66	10.28	9.87	625

[1]DAS- Days after sowing

[2]DATS1, 2- Days after treatment spray 1, 2

[3]FBD – Fruiting bodies damage

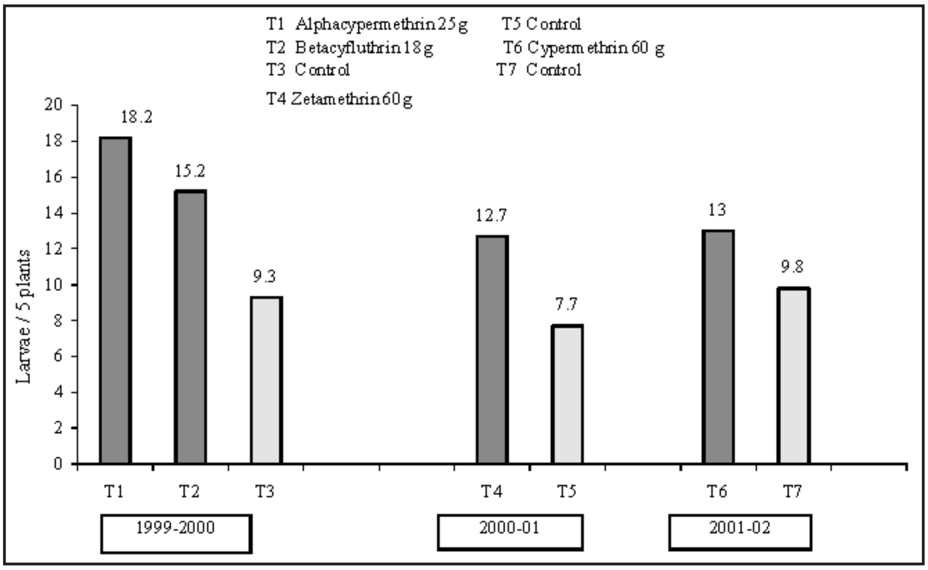

Figure 1. *Larval increase of H .armigera after two to three applications of insecticides.*

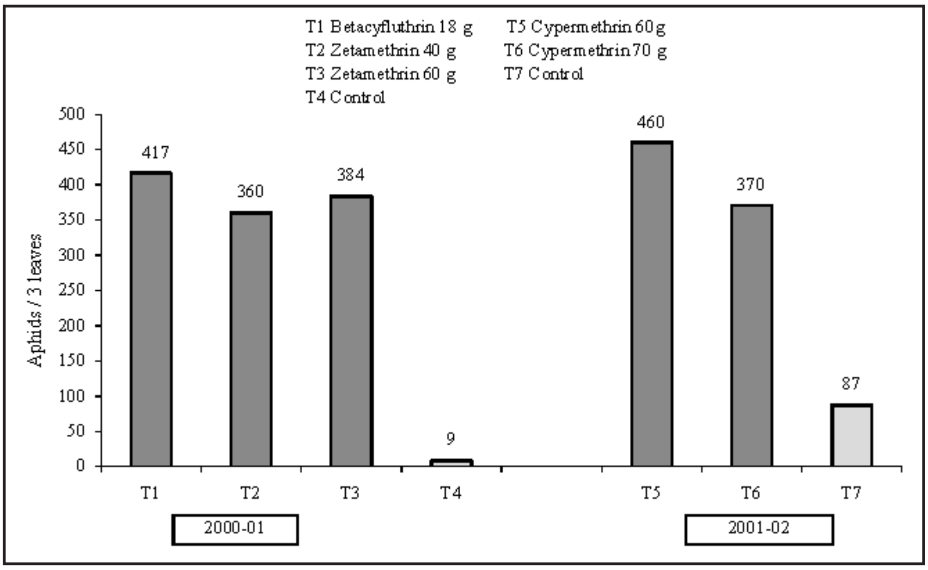

Figure 2. *Upsurge of A. gossypii after four to five applications of insecticides.*

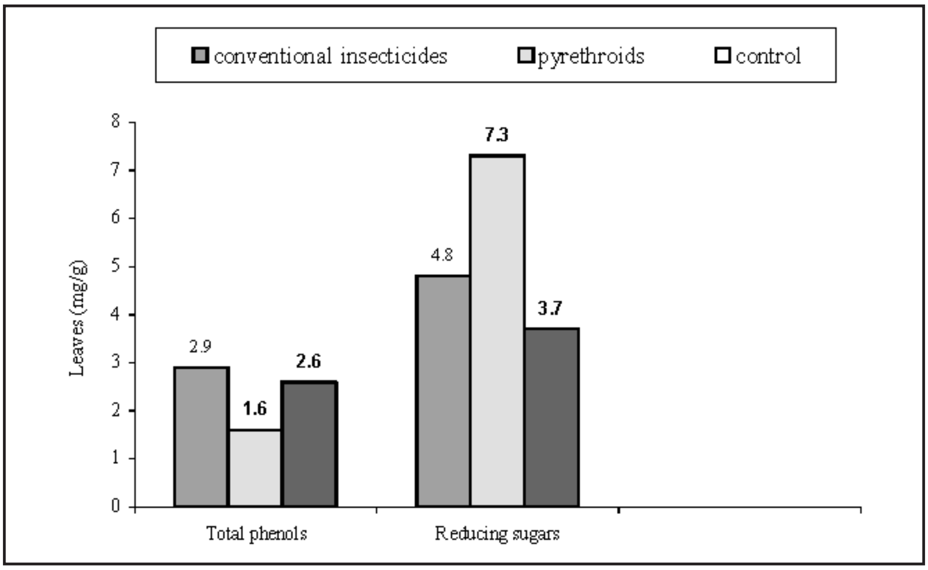

Figure 3. *Insecticidal influence on biochemical substances.*