

AREA WIDE IMPLEMENTATION OF INSECTICIDE RESISTANCE MANAGEMENT STRATEGIES ON BT COTTON – A CASE STUDY IN INDIA

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Received: September 30, 2008

Accepted: February 4, 2009

Abstract: Insecticide Resistance Management strategies have been formulated with several cost effective, ecofriendly novel approaches and rotation of insecticides based on resistance data for managing the pest complex for stabilizing the cotton ecosystem and improving the social economic status of the cotton growers. Insecticide Resistance Management (IRM) strategies for managing cotton pest complex revealed that sucking and bollworm complex was lower in IRM fields compared to non IRM fields. The strategic positioning of insecticides coupled with ecofriendly technologies led to abundance of natural enemies in cotton ecosystem in IRM fields, while the incidence of these insects was lower in non IRM fields due to insecticidal sprays. Farmers by adopting IRM strategies realized higher net returns by saving in plant protection cost due to less number of insecticidal sprays and increased seed cotton yield.

Key words: Bt cotton, IRM, bollworm complex, natural enemies, Guntur district

INTRODUCTION

Cotton is one of the most important commercial crops in India that consumes huge quantities of insecticides for managing pest complex. In India out of Rs.2800 crores (686.66 million \$) worth of chemical pesticides used in agriculture, Rs.1600 crores (381 million \$) worth was spent on cotton crop for the control of boll worms and sucking pests (Ghosh 2001). Cotton is extensively cultivated in entire Andhra Pradesh, which is one of the important agrarian states in India under diverse farming situations with high inputs. Cotton is highly vulnerable to pest attack and insect pests cause losses up to 87% in seed cotton yield (Taley *et al.* 1988). Among insect pests aphids [*Aphis gossypii* (Glover)], jassids [*Amrasca biguttula biguttula* (Ishida)], whiteflies [*Bemisia tabaci* (Genn.)], thrips [*Thrips tabaci* (Linde.)] and boll worm complex viz., American boll worm [*Helicoverpa armigera* (Hub.)], tobacco caterpillar [*Spodoptera litura* (Boisd.)] and pink bollworm [*Pectinophora gossypiella* (Saund.)] are considered to be the major constraints in Andhra Pradesh, India. Hence cotton growers completely rely upon pesticides for the control of insect pests of cotton. Insecticides obviously brought a considerable protection to crop yield especially during the initial phase of their development. Indiscriminate usage of chemical pesticides on the long run resulted in efficacy, besides development of resistance, resurgence of minor pests, and eradication of bioagents with adverse effect on human and beneficial organisms as well as environmental degradation. The Insecticide Resistance Management (IRM) strategies have been formulated with cost

effective, ecofriendly novel approaches and rotation of insecticide based on resistance data formulated for stabilizing of the cotton ecosystem and improving a social economic status of cotton growers. The strategies have been implemented on large scale by the farmers in Guntur district of Andhra Pradesh in India.

MATERIALS AND METHODS

For the implementation of IRM strategies during 2007–2008 fifteen villages selected in two mandals of Guntur district of Andhra Pradesh, India. Forty to seventy farmers from each village were involved in the transfer of technology. A total of 840 farmers were involved in technology transfer in the area of 2,460 ha. In both IRM and non IRM fields sowing was completed from July 15th to 30th July, 2007. The major cotton hybrids Mallika Bt and RCH 2 Bt were cultivated in both IRM and non IRM fields.

Insecticide Resistance Management strategies adopted in IRM fields/villages

- Farmers were advised to grow resistant hybrids to sucking pests and bollworms.
- Seed treatment with imidacloprid 70 WS (Goucho) @ 5 gm/kg of seeds or thiomethaxam 70 WS (Crusier) 4 gm/kg of seeds to delay the first spray against sucking pests up to 30 days, in order to help to build up of natural enemy population.

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- Stem application of monocrotophos (1:4 dilution) at 40 DAS and 60 DAS as a prophylactic measure against sucking pest complex especially jassids and aphids.
- No spray up to 60 DAS for early sucking pests.
- Intercrop with cowpea was recommended to enhance building up of natural enemies.
- Optimum use of chemical fertilizers, especially nitrogen fertilizers was recommended.
- Avoidance of a broad spectrum of organophosphates such as monocrotophos, acephate etc. as early sprays.
- Insecticides' usage pattern in different windows.

WINDOW 1: 60–90 DAS

- Hand picking of surviving larvae.
- NSKE 5% or neem based insecticides.
- Endosulfan for the control of *Spodoptera*.

WINDOW 2: 90–120 DAS

- Conventional insecticides like endosulfan, thiodicarb and chlorpyrifos.
- New molecules such as spinosad, emamectin benzoate, novaluron or indoxacarb.

WINDOW 3: > 120 DAS

- Pyrethroids for the control of pink boll worm.

Non participated farmers in Insecticide Resistance Management strategies (non IRM) were chosen from the same villages. The incidence of sucking pests and bollworm complex along with predator status was recorded from 30 IRM fields, in two locations from each village. Ten plants were randomly collected from each field and the data was recorded at a weekly interval. The incidence of jassids, aphids, whiteflies and thrips was recorded from 3 leaves/plant taking each leaf from the top, middle and bottom portions. At the same time the *Helicoverpa* egg

and larvae, *Spodoptera litura* infested plants, squares and pink boll worm infestation were also taken into account. One field from each village was selected as a control (Non IRM). Weekly data was pooled and the seasonal mean data was compared with the t-Test (SPSS 10.0 software for windows).

RESULTS

Impact of IRM strategies on cotton in Guntur district during 2007–2008

Incidence of sucking pests

The data on the incidence of sucking pests in IRM fields revealed that aphid incidence was low during early part of the season with peak levels in October showing seasonal mean incidence of 5.47/3 leaves and 8.06/3 leaves in non IRM fields with a significant difference. Among the sucking pests jassid was the major pest and considerable activity was observed from October to December with peak activity of 4.5/3 leaves in October in IRM fields. The seasonal mean was significantly lower in IRM fields (2.18/3 leaves) compared to non IRM fields (3.40/3 leaves).

Whitefly infestation was observed from November to January with its activity peak of 4.8/3 leaves in IRM fields and 7.9/3 leaves in non IRM fields which were seen in the same period i.e. December. There was a significant difference in seasonal mean of whitefly population between IRM and non IRM fields and recorded data amounted to 2.35/3leaves and 3.56/3leaves respectively. The level of incidence of thrips in IRM and non IRM fields was seen in the same period i.e. in September and October, however the seasonal incidence mean was higher in IRM (7.88/3leaves) compared to non IRM fields (6.13/3 leaves) with a significant difference (Table 1).

Table 1. Seasonal mean of sucking pests, bollworm complex and natural enemies in IRM and non IRM fields during 2007–2008

Sucking pests	IRM fields	Non IRM fields	t-Test
Aphids/3 leaves	5.47	8.06	Sig
Jassids/3 leaves	2.18	3.4	Sig
Whitefly/3 leaves	2.35	3.56	Sig
Thrips/3 leaves	6.13	7.88	Sig
Bollworm complex			
<i>Helicoverpa</i> eggs/plant	0.04	0.10	Sig
<i>Helicoverpa</i> larvae/plant	0.05	0.083	NS
<i>Spodoptera</i> infested plants %	0.71	1.28	Sig
<i>Pectinophora</i> larvae/boll	0.01	0	–
Natural enemies			
Coccinellids	0.416	0.15	Sig
Chrysoperla	0.06	0.01	Sig
Spiders	1.11	0.01	Sig

Incidence of boll worms

The data on American boll worm, *Helicoverpa armigera* infestation revealed that egg population was very low during the year and among the months under observation peak of egg laying observed in December was 0.35 eggs/plant in IRM fields (Fig.1). The damaging stage of *Helicoverpa* in cotton i.e. larval population was very low ranging from 0.01 to 0.2 larvae/plant, however the mean seasonal incidence between IRM fields (0.05/boll) and non IRM fields (0.083/boll) showed non significant difference.

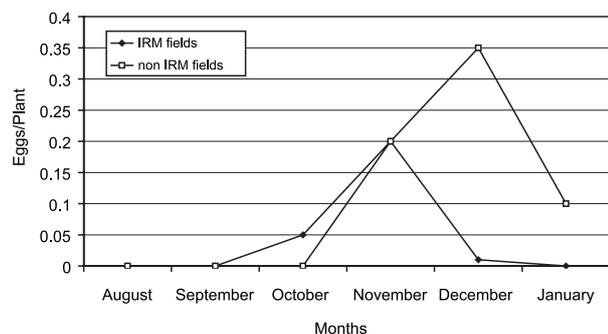


Fig. 1. Incidence of *Helicoverpa* egg population on Bt cotton in IRM and non IRM fields during 2007-2008

The Tobacco caterpillar *Spodoptera litura* infestation was almost absent during the initial phase of plant growth i.e. August and September both in IRM and non IRM fields. The pest infestation was initiated in October and amounted to 0.9% (IRM) and 1.5% (non IRM) of infested plants but the major activity of the pest was confined during November and December with peak levels of 2.3% and 3.65% infested plants in IRM and non IRM field respectively (Fig. 2).

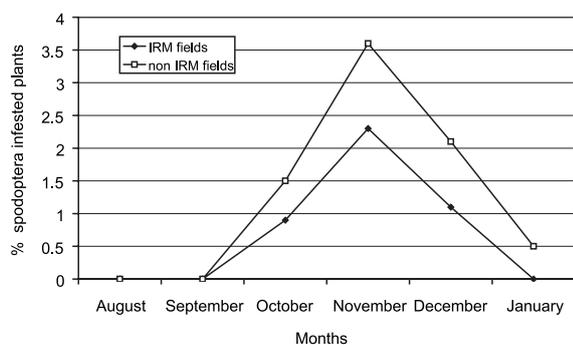


Fig. 2. *Spodoptera* infested plants on Bt cotton in IRM and non IRM fields during 2007-2008

The incidence of pink bollworm was negligible during the season and it was seen very late in December and January only in IRM fields with recorded data of 0.01 and 0.05 larvae/boll respectively.

Occurrence of natural enemies

During the cropping season the activity of spiders, coccinellids and chrysopids was noticed early on the crop the season i.e. upto 90 days, thereafter abundance gradually decreased. The mean of seasonal activity of spiders (1.11/plant), coccinellids (0.41/plant), and chrysopids (0.06/plant) was higher in IRM fields compared to non IRM fields (0.17, 0.15 and 0.01/plant respectively).

Economics

An average of 6 rounds of insecticidal spraying were imposed in IRM fields compared to 10 rounds of insecticidal spraying in non IRM fields. Cost of plant protection was 1.66 times higher in non IRM fields with Rs. 7,800/ha (185.71\$/ha) in contrast to lower investment of Rs. 4,700/ha (111.9 \$/ha) in IRM fields. The average seed cotton yield per hectare was significantly higher in IRM fields (33.4 Q/ha) compared to non IRM fields (31.5 Q/ha). Though there was a slight variation in yield, there was a considerable difference in net returns with Rs. 34,950/ha (832.1 \$/ha) in IRM fields compared to Rs. 28,070/ha (668.3 \$/ha) in non IRM fields, which resulted in higher net returns to farmers who adopted IRM strategies (Fig. 3).

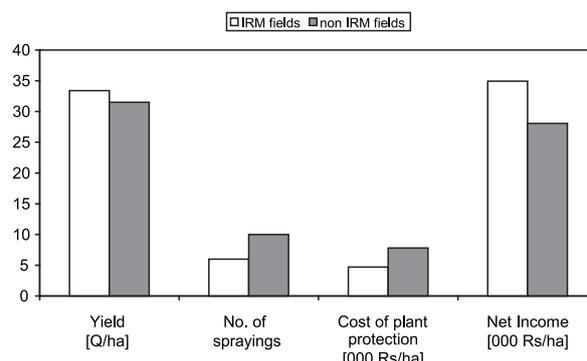


Fig. 3. Yield and Economics of IRM and non IRM fields during 2007-2008

DISCUSSION

Impact of IRM – strategies on cotton in guntur district during 2007-2008

Incidence of Sucking Pests

By implementing IRM strategies the major sucking pests of cotton were controlled effectively and presented study revealed that seasonal mean incidence of aphids, jassids and whitefly were lower in the IRM fields compared to non IRM fields. A low incidence in IRM fields could be attributed to ecofriendly technologies like seed treatment, stem application with insecticides, conservation of natural enemies by growing intercrops coupled with the low usage of insecticides for sucking pests. According to Mohapatra and Patnaik (2006) seed treatment with imidacloprid suppressed the sucking pests and also attributed to conservation of natural enemies in IPM plots. Wang *et al.* 1994 reported that painting of stems with 7% monocrotophos or carbofuran was the most effective method compared to spraying and seed treatment against aphids in cotton. Ramarao *et al.* 1998 reported that stem application with imidacloprid (200 SL) at 1:20 dilution at 20, 40, 60 DAS was highly effective in controlling aphids, leaf hoppers and mealy bugs in cotton. Seasonal mean incidence of thrips was higher in IRM fields compared to non IRM fields. This may be due to a lack of proper ecofriendly technology and the minimum rounds of insecticides used in IRM fields that were not sufficient enough to control the thrips, whereas the heavy insecticidal usage in non IRM fields effectively checked the thrips population.

Incidence of bollworms

The incidence of *Helicoverpa armigera* presented in IRM and non IRM fields the very low and the differences were non significant. Since transgenic Bt cotton was grown both in IRM and non IRM fields the Bt toxin in cotton affected suppressing the population of *Helicoverpa*. A low infestation managed efficiently in IRM fields by judicious use of insecticides in early stage helped to conserve natural enemies which in turn were able to suppress the minimum population available in IRM fields so insecticidal application was not warranted. In non IRM fields the usage of insecticides controlled the population.

The *Spodoptera* infestation observed in the middle stage of the crop was managed with single round of insecticide spray based on ETL coupled with some mechanical practices like removal of egg masses in IRM fields, whereas in non IRM fields 2 to 3 insecticidal sprays were given without following ETLs and mechanical practices to suppress the larval population.

The pink bollworm infestation was absent in non IRM fields and negligible in IRM fields. The Cry1Ac protein present in Bt cotton perhaps successfully reduced pink bollworm infestation to greater extent in IRM fields and resulted in a low level of the pest evidence without any insecticidal interventions. In non IRM fields the infestation was completely absent because of Cry1Ac protein presence in Bt cotton and insecticidal interventions. The transgenic Bt cotton cultivars expressing Cry1Ac toxin were proved highly toxic to American boll worm, pink boll worm, and spotted boll worms (Perlak *et al.* 1991).

Occurrence of natural enemies

Seasonal mean data on the occurrence of natural enemies like coccinellids, chrysopa and spiders were high in IRM fields because of less number of insecticide spraying and ecofriendly interventions like stem application of insecticides, cowpea as inter crop and seed treatment, whereas in non IRM fields the natural enemy population was lower due to heavy usage of insecticides. The presented results results of observations were corroborated with the findings of Puri *et al.* 1997; Sharma *et al.* 2001; Laveker *et al.* 2001 who reported abundance of natural enemies by growing intercrops.

Economics

By implementation of IRM strategies farmers had realized higher seed cotton yield with a low investment on insecticides by reduced number of insecticidal sprays. Monetary benefit of Rs. 6880/ha (163.80\$/ha) was achieved by farmers in IRM fields by saving in plant protection cost and increased seed cotton yield compared to non IRM fields. The IRM strategies let the farmers reduce the number of insecticidal sprays on cotton and consequently reduce plant protection cost, preventing development of resistance to insecticides and environmental risk and finally achieve sustainable cotton ecosystem in addition to higher net returns from cotton cultivation. According to Patil *et al.* (1992) IPM module realized the higher seed cotton yield with higher cotton cost benefit ratio.

ACKNOWLEDGEMENTS

The senior author is thankful to Dr. K.R Kranthi, Central Institute of Cotton Research, Nagpur, India for providing financial assistance for implementing the IRM project in Guntur district of Andhra Pradesh, India.

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POLISH SUMMARY

ZASTOSOWANIE NA SZEROKĄ SKALĘ STRATEGII ZAPOBIEGANIA ODPORNOŚCI NA INSEKTYCYDY W UPRAWIE BAWELNY BT – BADANIA PROWADZONE W INDIACH

Strategie zapobiegania odporności na insektycydy opracowano z uwzględnieniem takich aspektów jak – opłacalność produkcji, dobór środków przyjaznych dla środowiska, rotacja insektycydów oparta na bazie danych dotyczących odporności na insektycydy celem stabilizowania ekosystemu w uprawie bawełny oraz poprawienie sytuacji materialnej plantatorów bawełny. Praktyczne zastosowanie strategii zapobiegania odporności na insekty-

cydy (IRM – Insecticide Resistance Management) w celu kompleksowego zwalczania szkodników wykazało, że nasilenie występowania szkodników ssących oraz atakujących torebki nasienne było niższe na polach objętych strategiami IRM, w porównaniu do pól kontrolnych. Strategiczny dobór insektycydów w połączeniu ze sprzyjającymi środowisku technologiami doprowadził do wzrostu liczebności populacji naturalnych wrogów szkodników bawełny na polach, gdzie wykorzystano strategię IRM, w przeciwieństwie do pól kontrolnych (bez stosowania

strategii IRM), na których nasilenie szkodników ograniczono głównie, dzięki zabiegom opryskiwania insektycydami. Wykorzystując strategię zapobiegania odporności na insektycydy plantatorzy bawełny przekonali się, że uzyskany wyższy dochód z uprawy tej rośliny był spowodowany zaoszczędzeniem kosztów ochrony roślin, dzięki zredukowanej liczbie zabiegów opryskiwania insektycydami oraz jednoczesnemu wzrostowi plonu nasion bawełny.