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Validation of Insecticide Resistance Management (IRM) Based Integrated Pest Management (IPM) strategies for the Management of pink bollworm *Pectinophora gossypiella* (Saunders) in *Bt* cotton

M. Sivarama Krishna*, L. Vijaya Bhaskar and N.C. Venkateswrlu

Regional Agricultural Research Station, Nandyal 518 502, Andhra Pradesh, India

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ABSTRACT

A two year field study was conducted on validation of IRM based IPM strategies for the management of pink bollworm in *Bt* cotton in nearly twenty cotton farmer fields during 2021-22 and 2022-23 in selected villages of Kurnool district under IRM-Pink bollworm management project sponsored by Central institute for cotton Research, Nagpur. During the year 2021-22 IRM demo plots had recorded green boll, open boll and locule damage of 9.5, 10.2, and 6.25% respectively where as non IRM plots had recorded 21.8, 22.4 and 14.2% respectively. During the year 2022-23 IRM plots recorded green boll damage, open boll and locule damage of 8.2, 9.6 and 7.1% respectively where as non IRM plots recorded 20.2, 20.8 and 14.49% respectively. Average insecticidal sprays during both years in IRM farmer fields were 3.85 where as in non IRM plots it was 6.85, IRM farmer had registered a average benefit -cost ratio of 1.16:1 where as in non IRM practice it was 0.33:1.

***Key words**: Pink bollworm, Insecticide resistance management, Green boll damage, Pheromone traps.*

Introduction

Cotton (*Gossypium hirsutum* L.) is an important commercial crop playing a important role in sustaining economy of India and livelihood of the Indian farming community. Insect pests and diseases are the major biotic constraints for successful cotton production. In India, 162 species of phytophagous insects have been recorded on the cotton crop, of which 24 species have attained pest status and nine are key pests in one or more cotton growing zones of the country (Dhawan, 2000). Injudicious use of chemical pesticides has caused harm due to pesticide residue, resurgence, secondary pest outbreak and development of resistance against these chemical molecules. Many of the insect pests infesting cotton in different agro-climatic zones are common but some are more serious in particular zone due to the conditions favouring their buildup. Emerging pest problems like pink bollworm *Pectinophora gossypeilla* (Saunders) (PBW) threatened cotton production in the Central Zone of the country since 2016 onwards. *Pectinophora gossypiella* (Saunders), is one of the most damaging insect pests of cotton, with a wide range that causes significant losses in cotton production across India (Dhurua and Gujar, 2011) The damage to lint is so severe that often the crop has to be abandoned from picking as the bad seed cotton has no market appreciation. This bollworm threatened farmers so much that inte-

grated pest management (IPM) in cotton took off roots in order to suppress it smartly and with less cost. Pink bollworm has evidently come under increasing selection pressure to evolve resistance to Bt protein(s) produced in tissues of cotton plants. Secondly, even as an alternative control method, conventional insecticides have limited efficacy on PBW due to the internal feeding habit of the larvae within the developing cotton boll. The fruiting bodies formed in the later part of the season became prone to the attack of pink bollworm; therefore, the farmers apply cock tail mixture of chemical insecticides which results in resistance problem and exacerbating the cultivation costs. Under these circumstances, there is a dire need for environmentally sound and eco friendly management practices against major pests of cotton including pink bollworm. Therefore, the present study aimed to validate IRM strategies for cotton with major emphasis on pink bollworm.

Materials and Methods

A Field study was conducted during the year 2021-22 and 2022-23 to validate IRM strategies for pink bollworm *Pectinophora gossypiella* (Saunders) in Bt cotton in nearly twenty farmers fields in selected village of Kurnool district of Andhra Pradesh under Insecticide Resistance Management-Pink bollworm management project funded by ministry of Agriculture and central institute for cotton research as a nodal implementing agency. One acre from each farmer was selected as demo plot where all the prescribed pink bollworm management strategies were demonstrated, five non IRM farmers were also selected from the village for comparison where farmer practices were implemented in these fields. Prescribed recommended insecticides for the management of pink bollworm as critical inputs were distributed to IRM farmers for an acre, i.e. Neemoil @ 1000 ml, Thiodicarb@ 300g, Profenophos@400 ml, Chloropyriphos@500 ml, Lamda cyhalothrin@ 200 ml and pheromone traps@ four per farmer. The recommended insecticides were sprayed in recommended dosages as prescribed by Agricultural university after pink bollworm crossing economic threshold levels, i.e. eight to ten adult moth catches in pheromone traps for consecutive three days and 10% green boll observed during destructive sampling. Along with chemical inputs IRM famers also demonstrated other integrated pink bollworm management strategies as prescribed by central institute for cotton research, Nagpur (Table 1). Data on pheromone trap catches standard week wise, green boll damage, number of insecticidal sprays, volume of insecticide applied, yield and B:C ratio was recorded from twenty IRM and five non IRM farmers and averaged.

Results

During 2021-22 the results indicate that the mean rosette flower damage, green boll damage , open boll damage at 110 and 13 DAS , and locule damage were 2.7, 9.5, 10.7,10.2, and 6.25 % in IRM demo plots where as non IRM farmer plot had registered a damage of 4.0, 21.8, 17.9, 22.4, and 14.2 respectively. Average pink bollworm pheromone trap catches/trap/week was recorded as 19.3 as against 47.6 in non IRM plots, average insecticidal sprays of IRM farmer was 3.8 as against 6.9 in non IRM farmer. IRM demo farmer plot had recorded a yield of 2027kg/ha where as non IRM demo plot farmer had recorded a yield of 1498 kg/ha, during the year 26% reduction in usage of insecticide was registered over non IRM farmer with benefit cost ratio of 1.19:1 where as non IRM farmer had registered a B:C ratio of 0.39:1 (Table 2,5,6).

During 2022-23 the results indicate that the mean rosette flower damage, green boll damage , open boll damage at 110 and 13 DAS , and locule damage were 1.9, 8.2, 9.9, 9.6, and 7.1 % in IRM demo plots where as non IRM farmer plot had registered a damage of 3.0, 20.2, 16.7, 20.28, and 14.4 respectively. Average pink bollworm pheromone trap catches/trap/week was recorded as 21.54 as against 59.1 in non IRM plots, average insecticidal sprays of IRM farmer was 3.9 as against 6.8 in non IRM farmer. IRM demo farmer plot had recorded a yield of 2061kg/ha where as non IRM demo plot farmer had recorded a yield of 1457 kg/ha, during the year 5.7% reduction in usage of insecticide was registered over non IRM farmer with benefit cost ratio of 1.13:1 where as non IRM farmer had registered a B:C ratio of 0.27:1 (Table 3,5,6).

Discussion

Liu *et al*. (1997 and 2002) found that providing refuge of the host plants to pests that do not make Bt proteins, i.e., non Bt crop. Refuge allows survival of insects that are susceptible to Bt proteins and reduces the chances that two resistant insects will

mate and produce resistant offspring. This strategy is particularly effective for delaying resistance. This concept was widely accepted by eminent scientist working on IRM strategies.

Aggarwal *et al*. (2006) reported that the results demonstrated the superiority of IRM strategy over the present farmer's practice unnecessary use of insecticides, and practically no monitoring where a significant increase in cotton yield was observed

Aggarwal *et al*. (2006) recorded the number of insecticide sprays per season in IRM plots (9.5) was less than in non-IRM plots (14.5).

The above results are also supported by the reports of Anonymous in 2007 and 2009 in which the multi-location trials conducted at Rahuri, Maharashtra, Warangal and Rajendranagar (AP) and Coimbature (TN) showed similar results

Dhawan *et al*. (2009) reported that Cotton yield

Table 1. Stage wise Integrated Insecticide resistance management strategies adopted by *Bt* cotton farmer

Operation	IRM recommendations
Sowing	Timely sowing, i.e. July month wherever applicable Use jassid tolerant, short duration Varieties/BGII hybrids recommended for the region
Refugia	Refuge planting (120 g non Bt) around Bt cotton or separate as strip if supplied with seed packet or cultivation of Bt cotton provided with refuge- in-built.
Monitoring	Install pheromone traps @ 4/acre for monitoring pink bollworm moth activity at 45 DAS
Pesticide	➢ Spray of Neem oil @ 5 ml/l of water at 50 DAS, At boll formation stage, farmers are advised to inspect presence and damage of PBW by plucking 20 green bolls from different plants randomly (one boll per plant). ETL at this stage is 10% damaged green bolls (at least two bolls having white or pink larvae). ➢ Spray of Thiodicarb 75% WP 1.5 g/l of water at 100 DAS ➢ Spray of Chlorpyriphos 20% EC 25 ml or 2.0 ml/l water at 110 DAS ➢ At 90 Days after sowing release of the egg parasitoid *Trichogramma bactrae* @ 60,000 eggs /acre. ➢ At 120 Days after sowing spray of Lamda cyalothrin 5% EC 10 ml/ 10 L water
Crop termination	After 150 days after sowing termination and Uprooting of the crop not extending the cotton crop beyond 180 DAS Cleaning up fields of residual stalks and partially opened bolls.

Table 2. Impact of Insecticide Resistance Management (IRM) based Integrated Pest Management (IPM) Strategies on green boll, open boll and locule damage during 2021-22

	IRM fields	Non IRM fields	T test
Mean percentage rosette flower incidence	2.7	4	Sig
Mean percentage of Green boll damage at 90DAS	9.5	21.8	Sig
Mean percentage of Open boll damage at 110 DAS	10.7	17.9	Sig
Mean percentage of Open boll damage at 130 DAS	10.2	22.4	Sig
Mean percentage of Locule damage at harvest	6.2	14.2	Sig
Ave Pheromone trap catches/trap/week	19.3	47.6	Sig
Ave no of insecticidal sprays	3.8	6.9	Sig
Ave Yield in Kg/ha	2027	1498	Sig

Table 3. Impact of Insecticide Resistance management (IRM) based Integrated Pest Management (IPM) strategies on green boll, open boll and locule damage during 2022-23

	IRM fields	Non IRM fields	T test
Mean percentage rosette flower incidence	1.9	3	Sig
Mean percentage of Green boll damage at 90 DAS	8.2	20.2	Sig
Mean percentage of Open boll damage at 110 DAS	9.9	16.7	Sig
Mean percentage of Open boll damage at 130 DAS	9.6	20.8	Sig
Mean percentage of Locule damage at harvest	7.1	14.4	Sig
Ave Pheromone trap catches/trap/week	21.54	59.1	Sig
Ave no of insecticidal sprays	3.9	6.8	Sig
Ave Yield in Kg/ha	2061	1457	Sig

Table 5. Impact of IRM on the Benefit Cost ratio during the years 2021-22& 2022-23

Year	Cost of spray (Rs/ha)		Cost of cultivation (Rs/ha)		Net profit (Rs/ha)		Additional profit due to IRM (Rs/ha)		Benefit Cost Ratio	
	IRM	Non IRM	IRM	Non IRM	IRM	Non IRM	IRM	Non IRM	IRM	Non IRM
2021-22	8500	11,500	69,400	80700	82625	31650	50975		1.19	0.39
2022-23	9800	10,400	67,650	80140	76620	21850	54770		**1.13**	0.27
Mean	9150	10950	68525	80420	79622	26750	52872		**1.16**	0.33

** Cost of kapas during 2021: Rs 75/Kg
Cost of kapas during 2022: Rs 70/Kg

Table 6. Reduction in pesticide usage in IRM Vs nonIRM fields

Year	Cost of spray in IRM in Rs (A)	Cost of spray in non IRM in Rs (B)	Difference (C) in RsA-B	Reduction in usage % C/Bx100
2021-22	8500	11500	3000	26.0
2022-23	9800	10400	600	5.7
Mean	9150	10950	875	15.8

significantly increased in IRM adopted villages as compared to non-IRM practicing as revealed in an analytical study of IRM strategies of cotton adopted by cotton growers of Punjab

Peshin *et al*. (2009) reported Under the IRM-IPM programme in Punjab 30% reduction in insecticides consumption and 15% reductions in number of sprays were recorded

Sandhya Rani *et al*. (2010) studied the efficacy of pheromone traps such as sleeve trap and yellow funnel was well demonstrated by some researchers

Patil *et al.* (2011) reported Adoption of IRM based IPM modules has resulted into reduction in population of sucking pests over recommended plant protection practices with lesser use of insecticides

Patil *et al.* (2011) reported the adaptability of IPM module integrated with Bt cotton genotypes proved superior by recording least percentage of infestation and higher seed cotton yield with more net returns

The above results are in corroboration with the results of Rishi Kumar *et al.* (2012) who reported that large scale field evaluation of the technology indicated the reduction in number of insecticidal sprays (30.65%, 24.29% in 2007-08 and 2008-09, respectively) and shift in pesticide use pattern in adopted villages and also total consumption of insecticides was 26.79% and 31.24% higher during 2007-08 and 2008-09, respectively in Non-IRM over IRM villages.

Patil *et al.* (2014) reported that Under IPM technology, higher net profit was recorded from Bunny BG-II followed by Nathbaba (Rs. 103905.00/ha). On the contrary net profit in non Bt IPM module was more compared to the farmer practice.

Conclusion

From the above study it can be concluded that by adopting Insecticide resistance management (IRM) based integrated pest management (IPM) strategies in Bt cotton pink bollworm can be efficiently managed. Relying on chemical insecticides alone for the management of pink bollworm is not sustainable and increases cost of cultivation and reduces net returns.

Conflict of Interest: None

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