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EFFECT OF IPM/IRM STRATEGIES FOR PINK BOLLWORM, *PECTINOPHORA GOSSYPIELLA* SAUNDERS INFESTING *BT* COTTON

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ABSTRACT

*Farmers had initiated indiscriminate use of insecticides against pink bollworm and incurred high cost of managing. Unless extension initiatives to create awareness to manage pink bollworm, the situation may further lead to yield losses, distress of cotton farmers and threat to sustainability that in turn will have a cascading effect on textile industries and economy. Keeping in view, pink bollworm management strategies comprising of timely sowing, use of refuge, recommended nutrition, monitoring through pheromone traps, release of bio-control agent, recommended insecticide sprays at ETL, field sanitation and timely termination of the crop formulated by ICAR-CICR, Nagpur were disseminated and demonstrated to 50 beneficiary farmers in irrigated tract of Valia taluka of Bharuch district. Amongst sucking pests population, aphid, thrips and leafhopper had crossed ETL once and whitefly and mealybug remained below ETL during the season in IRM-FLD plots whereas aphid, thrips and leafhopper crossed ETL 4, 1 and 5 times, respectively whereas whitefly and mealybug remain below ETL during the season in non-IRM plots. Sucking pests required average 2.90 sprays in IRM-FLDs plots whereas slightly higher 3.00 in non IRM plot. For pink bollworm management, 2.20 and 2.70 sprays were targeted by farmers under IRM and non-IRM plots condition, respectively. Seed cotton **y**ield varied from 830 to 979 kg/acre and from 810 to 968 kg/acre under IRM and non IRM condition, respectively. The net return was found higher in IRM plots (Rs. 21,500 to 27,875/acre) than the non IRM (Rs. 18,740 to 25,663/acre). The FLDs and outreach extension activities aided in educating and percolating technology to adjacent periphery of the region.*

Keywords*: Bt Cotton, IRM, pink bollworm, sucking pests*

INTRODUCTION

Cotton is an important commercial crop grown for fibre, fuel and edible oil. It plays an important role in Indian and state economy. Gujarat, Maharashtra and Telangana are the major cotton growing states accounting around 70 and 67 per cent of the area and cotton production, respectively in India. Gujarat ranks second in area (2.4 M ha) and first in production (9.5 M bales of 170 kg) in the country in the year 2016-17. The productivity of cotton in the Gujarat (673 kg ha^{-1}), though, higher than the national average (568 kg ha^{-1}) could be improved further. The production of cotton in the country for 2016-17 was 35.1 M bales making the largest producer of cotton worldwide, while the area under cotton cultivation was around 10.5 M ha (Anon., 2017). Cotton ecosystem is dominated by the *Bt* cotton in irrigated condition sown as early as April-May than recommended normal sowing of June-July in other areas without irrigation facility. At present, area under *Bt* cotton is >85 per cent of the total cultivated area and share of Bollgard II is dominant. The first report of severe pink bollworm infestation to *Bt* technology and resistance development to Bollgard (*Cry1Ac*) came in 2010 and subsequently to Bollgard II (*Cry1Ac* and *Cry2Ab*$_2$) during 2013-2014. Pink bollworm (*Pectinophora gossypiella* Saunders) has now emerged as a major pest of Bollgard II in parts of Central and South India. The pest mainly feed on seeds causing economic loss through reduction in yield and deterioration in quality (Rathwa *et al.,* 2021). Infestation of pink bollworm occurs in mid and late stage of the crop, remains undetected due to internal feeding behaviour and causes loss of yield and quality. Pink bollworm was a key pest of cotton in India accounting for yield losses to the level of 20 to 90 per cent, prior to the use of broad spectrum insecticides and introduction of transgenic cotton. World over, Pink bollworm is the most destructive pest of cotton and is known to cause 2.8 to 61.7 per cent loss in seed cotton yield, 2.1 to 47.1 per cent loss in oil content and 10.7 to 59.2 per cent loss in normal opening of bolls (Patil, 2003). Rathod *et al*., (2017) found that infestation of bollworms delayed by one or two weeks when sown early (May) compared to normal sowing time (June-July). The avoidable loss of seed cotton yield was estimated to be 7.33 and 5.43 per cent for RCH 2 BG I when sown early and normal time, respectively. Whereas, it was 5.05 and 3.32 per cent for RCH 2 BG II when sown at early and normal sowing time, respectively. For RCH 2 non *Bt* the avoidable

loss of seed cotton yield was estimated to be 42.63 per cent when sown early and 33.98 per cent when sown at normal time. Field assessment of losses in 274 surveyed villages of Bharuch and Surat districts in South Gujarat showed overall 2.14 per cent losses in seed cotton yield loss (Anon., 2018). Farmers had initiated indiscriminate use of insecticides against PBW and incurred high cost of managing. Unless extension initiatives to create awareness to manage PBW, the situation may further lead to yield losses, distress of cotton farmers and threat to sustainability that in turn will have a cascading effect on textile industries and economy. Keeping in view the project objective was implemented to educate cotton farmers through dissemination of PBWM strategies formulated by ICAR-CICR, Nagpur under the centrally sponsored project NFSM: CC: Cotton: IRM: Dissemination of Pink bollworm Management Strategies.

OBJECTIVE

To disseminate pink bollworm management strategies in *Bt* cotton

MATHODOLOGY

Considering previous infestation, bench mark survey and joint visits with line department, CIPMC and peripheral co-operative societies, the project was implemented in hotspot areas of Bharuch districts of Valiya and Jhagadia taluka where 50 Front Line Demonstrations (0.4 ha/beneficiary farmer) under Insecticide Resistance Management (IRM) umbrella with special emphasis to educate farmers and to disseminate effective IPM/IRM strategies to manage pink bollworm during 2018-19. Four villages of Valiya taluka (Desad, Tuna, Sodgam and Daheli) and one village of Jhagadia taluka (Dharoli) were selected. The senior research fellow and young professional-I hired under the project were trained for identification of pests and natural enemies, IPM/IRM strategies and modus operandi of the project for various records. The participatory farmers were convinced and educated for the pink bollworm management strategies to followed and critical inputs also supplied and awareness created for proper use. Insecticide Resistance Management strategies suggested by ICAR-CICR, Nagpur which was adopted in IRM fields/villages during 2018-19 as followed:

- Install pheromone traps @ 2/acre for monitoring PBW moth activity at 45 DAS
- Spray neem seed extract 5% + neem oil @ 50 ml/10 litre of water at 50-60 DAS
- Flonicamid 50 WG @ 4 g/10 litres of water (need based at ETL for sucking pests) after 60-90 DAS
- Release of egg parasitoid, *Trichogramma bactrae* @ 60,000 eggs/acre at 90-120 DAS
- Chlorpyriphos 20 EC @ 20 ml/10 litres of water at 90-120 DAS

The project staff along with participatory farmers monitored and scouted the incidence of the pests and maintained the data records and based on the strategies, management was followed. During participatory scouting, observations on sucking pests (aphid, thrips, leaf hopper, whitefly/3 leaves, mealybug grade/plants) were recorded on 10 randomly selected plants at fortnight interval initiating from 38th Standard Meteorological Week (SMW) to crop harvest from all 50 *Bt* IRM plots as well as 10 *Bt*-Non IRM plots. Damage to flowers was recorded from 10 plants during flowering period whereas damage to green bolls was recorded on 20 green bolls by destructive sampling during September to January. The damage to open bolls and locules was also recorded at harvest from 10 plants. Under this project, various extension activities *viz.,* diagnostic field visits, visit of farmers to demonstration, field trainings, farmers seminars, TV talk and kisan mela were organised and folders on production, protection and PBWM were distributed. Further, 23 e-voice advisories/messages were sent weekly in advance to 230 willingly registered farmers.

The seed cotton yield was also recorded on each of these plots. The output/ resultant impact of implementation was analysed/evaluated based on the comparative infestation and damage of the pests, feedback and economics of participatory and non-participatory farmers as well as visual observations on quality of the produce in the adjacent ginning factories.

RESULTS AND DISCUSSION

Season and Crop condition

In Bharuch, the monsoon was started with 27.0 mm rain on 25th June, 2018. An effective rainfall of 81.4 mm was received during 27th Standard Meteorological Week. Sowing of cotton experiments was started during last week of June and most of experiments almost sown by 2nd week of July. Thereafter, the heavy rainfall of 259.7 mm was received within seven days during 11th to 17th July, resulted water logging condition for several days in most of the plots. There was an adverse effect on germinated cotton plants and some were dried. An addition rain of 118.6 mm was received up to end of July helped good germination. The germination was good even though plant population was maintained by gap filling. The scattered rainfall of 163.6 mm was received between first week of August and 4th September, 2018 and it was very favourable crop growth in rainfed condition.

The monsoon was almost end at 1st week of September, except only 7.0 mm rainfall on 23rd September, 2018. There was a dry spell for crop grown under rainfed condition, particularly during reproductive stage, affect some extent on crop production. In all, 680.2 mm rainfall was received in 29 rainy days. All the cultural operations and plant protection measures adopted timely resulted in good crop condition till to maturity stage of the crop. During vegetative stage of cotton crop, thrips was found above ETL during end of September. Jassids were observed throughout the season and crossed threshold level many times. Population of whitefly and aphids were low to moderate whereas, high infestation of mealybug was found during later stage of the crop. At flowering stage, pink bollworm infestation was initiated in non *Bt* and *Bt* cotton however, at boll stage; its damage was lower compared to previous three seasons. Other two bollworms *i.e. Helicoverpa* and *Earias* were moderate to high on different cotton varieties. The lower population of *Spodoptera* larvae was recorded on cotton crop. No severe incidence of diseases was observed during the season.

Incidence of pests and their management

Sucking pests

Table 1: Incidence of sucking pests in IRM project villages of cotton at Bharuch district (2018-19)

Fields	Sept. I	Sept. II	Oct. I	Oct. II	Nov. I	Nov. II	Dec. I	Dec. II	Jan. I	Mean
Av. Aphids/ 3 leaves										
IRM	6.04	3.16	8.18	21.39	13.48	24.23	17.30	25.53	32.70	16.89
Non IRM	12.28	10.40	18.26	35.99	23.10	36.94	28.75	41.44	50.77	28.66
Av. Thrips/ 3 leaves										
IRM	30.26	11.39	15.72	13.11	7.76	5.20	3.48	1.36	0.47	9.86
Non IRM	36.53	26.10	22.02	13.21	10.69	7.65	4.21	0.97	0.39	13.53
Av. Leafhoppers/ 3 leaves										
IRM	3.69	1.89	5.64	7.04	3.40	4.49	2.21	0.98	1.33	3.41
Non IRM	6.62	5.50	10.96	10.58	8.49	7.04	3.18	2.02	1.20	6.18
Av. Whitefly/ 3 leaves										
IRM	2.17	1.38	3.94	7.84	4.16	4.77	2.68	2.04	2.52	3.50
Non IRM	5.70	6.90	6.51	11.80	7.05	7.02	3.61	2.00	1.40	5.78
Mealybug grade/plants										
IRM	0.00	0.04	0.28	0.60	1.07	1.02	0.85	1.18	1.73	0.75
Non IRM	0.00	0.00	0.41	0.78	1.38	1.56	1.05	1.84	2.67	1.08

Sucking pests *viz*., aphid, leafhopper, thrips, whitefly and mealybug population recorded from IRM and Non IRM plots (Table 1). Aphid population was started from September I fortnight and gradually increased with onset of winter with maximum population during November to January. Aphid crossed ETL 1 times under IRM condition whereas 4 times in non IRM during the season. Leafhopper appeared from September I fortnight and continued throughout the crop season with 1 peaks observed during October II fortnight on IRM cotton whereas it observed 5 peaks on non IRM in *Bt* cotton. In initial stage (September I fortnight), thrips population observed very high and crossed the ETL under IRM and non IRM *Bt* cotton hybrids. Whitefly and mealybug were found below ETL on IRM and non IRM plots except mealybug crossed ETL in non IRM plots during January I fortnight. Though, Whitefly appeared from I fortnight of September, its population remained below ETL throughout the crop season both in IRM and non IRM *Bt* cotton hybrids.

Thus, the above results revealed that the selection of insecticide using group rotation principle and spraying at ETL populations through effective scouting reduced the frequency of sprays by extending time to population build up at ETL level. IRM strategies through effective scouting the check on population built up unlike *Bt* cotton. Further, the overall mean population data of sucking pests revealed that the population pressure was remained low on account of advocating participatory IRM strategies in *Bt*-IRM compared to *Bt*-Non IRM plots. Prasad *et al.,* (2009) recorded that the aphid incidence was low during early part of the season with peak levels in October in IRM fields. They also observed that the incidence of sucking pest was lower in IRM fields compared to non IRM fields. Soni and Dhakad, (2016) recorded that the leafhopper population was active during the crop season and recorded it as a highly active during the September and October. Harde, (2018) recorded the activity of aphid, thrips, leafhopper, whitefly and mealybug in cotton crop during the crop season. Rajasekhar and Durga, (2018) and Desai *et al.,* (2019) did not find above ETL populations of whitefly but found above ETL population of mealybug at the end of the season.

Pink bollworm

Table 2: Damage to flowers and green bolls by pink bollworm in IRM project villages of cotton at Bharuch district (2018-19)

Fields	Sept. I	Sept. II	Oct. I	Oct. II	Nov. I	Nov. II	Dec. I	Mean
Rosette flower/10 plants (%)								
IRM	14.65	11.53	8.70	7.43	4.55	0.62	0.30	6.82
Non IRM	20.19	15.39	11.34	10.13	3.81	1.67	0.62	9.02
Green boll damage/20 green bolls (%)								
IRM	4.90	5.90	5.90	6.50	7.90	13.20	9.30	8.00
Non IRM	12.00	11.10	8.00	7.00	12.50	14.00	18.00	23.50
At Harvest								
	Open boll damage (%)				**Locule damage (%)**			
IRM	3.38				1.55			
Non IRM	7.66				3.28			

Pink bollworm infestation was recorded during September I fortnight to December I fortnight under IRM and non IRM plots (Table 2). Damage to rosette flower by pink bollworm crossed ETL in 2 times whereas 4 times in non IRM condition. Damage to rosette flower was below ETL or very less in IRM and non IRM plots during November to December month. Under IRM condition, green boll damage by pink bollworm was remained below ETL during the season except crossed ETL during November II fortnight whereas 7 times crossed ETL in non IRM plots. Further, open boll and locule damage by pink bollworm was below ETL at harvest. The present finding was almost in confirmation with Shinde *et al*., (2018) who reported flower rosetting, green boll damage and locule damage 1.77 to 15.73 per cent, 0.83 to 35.00 per cent and 0.44 to 18.79 per cent in *Bt* cotton, respectively. Desai *et al*., (2019) recorded highest larval population of pink bollworm in second fortnight of November in *Bt* IRM and *Bt* non IRM plots.

Number of sprays and insecticidal application

Table 3: Economics as influenced by *Bt*-IRM Strategies in comparison to Non-IRM farmers at Bharuch (2018-19)

Fields	Yield (kg/ acre)	Gross realiz-ation (Rs.)	Fixed cultiv-ation cost (Rs.)	Variable cost (Rs.)			Number of Spray		Total cost of plant protection		Picking cost (Rs.)	Total expen-diture (Rs.)	Net return (Rs.)	Sub-sidy
				Seed and sowing cost	Nutrient & appli-cation cost	Inter-culturing	SP	BW	SP	BW				
IRM	913	45655	5000	2050	2540	720	2.9	2.2	2431	1470	6392	20603	25052	1902
Non IRM	893	44650	5000	2050	2540	720	3.0	2.7	2101	3696	6251	22357	22293	-

Amongst sucking pests, aphid, leafhopper thrips and mealybug were found above ETL during the crop season which required average 2.90 sprays in IRM plots whereas slightly higher 3.00 in non IRM plots (Table 3). For pink bollworm management, 2.20 and 2.70 sprays were targeted by farmers under IRM and non IRM plots condition, respectively. Aggarwal, (2006) recorded the number of insecticide sprays per season in IRM plots (9.5) was less than in non-IRM plots (14.5). Due to the adoption of IRM strategies, Dhawan *et al*., (2009) and Dhawan and Randhawa, (2009) recorded 41.2% reduction in insecticidal sprays in Punjab. Desai *et al*., (2019) recorded average of 2.51 sprays required in IRM plots specifically for pink bollworm management as against 2.68 sprays in non IRM plots for all three bollworms.

Economics

Seed cotton yield (Table 3) varied from 830 to 979 kg/acre and from 810 to 968 kg/acre under IRM and non IRM condition, respectively. The net return was found higher in IRM plots (Rs. 21,500 to 27,875/acre) than the non IRM (Rs. 18,740 to 25,663/acre).

Extension activities carried out

Table 4: Extension activities carried out under the IRM project (2018-19)

Sr. No.	Extension activities	Numbers	Farmers benefited
1	Mobile/ Voice messages	23	230
2	Leaflet/folder/pamphlet distributed	5	2550
3	Diagnostics field visits	11	260
4	Exhibition arranged	01	150
5	Workshop/ training conducted	06	480
6	TV talks	02	Mass media
7	Farmer training organized	02	200
8	Farmers field school organized	02	200
9	Lecture delivered in training	07	190

Outreach extension activities for disseminating and educating farmers for effective management of PBW and sucking pests were taken up individually and jointly with different stakeholders including State departments, KVKs, agribusiness clinic/centers, seed, fertilizer and pesticide companies in the region (Table 4). Insect-pest advisory through mobile/e-voice message service can play an important role in assisting farmers to adopt need based timely IPM/IRM strategies. Under this, about 23 messages were sent which benefited 230 farmers registered in the villages. Two farmers training, two field school and six workshops were organized in which total 880 farmers participated. Exhibition arranged with live samples of different life stages of pink bollworm, pheromone traps and lures, early maturing public sector *Bt* hybrids, damaged flowers, green bolls and open bolls during farmers seminar/workshop at co-operative ginning factory updated and enhanced skill for easy identification for pest scouting and selection of short duration hybrids as farmers now asked maturity days of the any hybrids. Further, it created knowledge to input dealers and ginning mill owners. Five leaflets/folders/pamphlets on crop production and crop protection in *Bt* cotton were published and distributed to 2550 participated stakeholders. The knowledge acquired during the learning process enabled farmers to adopt IPM/ IRM strategies more profitably.

CONCLUSION

This project benefited 50 beneficiary farmers along with 25 Co-operative societies, 50 input dealers and increased the knowledge of 25,000 farmers indirectly. Farmers and ginners learnt the selection of components and safe use of IPM strategies. Farmers learnt to use better package of practices leading to efficient use of resources during the cultivation and guidance on timey and proper crop residue management.

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. 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. Through participatory approach IRM strategies must be followed for sustainability of the products and eco-friendly management of pests.

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CONFLICT OF INTEREST

The authors of the paper declare no conflict of interest

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