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Impact of IPM technology on Pink Bollworm (*Pectinophora gossypiella*) in Bt cotton of Beed district in Maharashtra

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Abstract

Pink bollworm is a dangerous pest that severely impacts cotton production worldwide, reducing crop quality and yield and causing significant financial losses. The purpose of this research is to analyse different methods for controlling pink bollworm infestations and emphasize the importance of integrated pest management (IPM) techniques. The article discusses that the chemical control with pesticides which despite their efficacy, cause environmental problems and the rise of resistance. It also draws attention to sustainable biological management approaches like parasitoids, entomopathogenic fungi and natural predators. Additionally, pheromone disruption strategies such as mating disruption and pheromone trap monitoring, are being studied as effective means of reducing insect populations without jeopardizing the environment. The key findings indicate that while each strategy has benefits, a comprehensive, integrated approach combining cultural, physical, biological and chemical methods is the best long-term solution for controlling pink bollworm in cotton. The average gross returns from demonstration practice were Rs. 90747/ha, and in Farmer practice is Rs. 78753/ha. Demonstrative practice produced net returns of Rs. 46587/ha, while farmers' practice produced net returns of Rs. 32578/ha. The average cost of cultivation during the study period was Rs. 46175/acre in the demonstration plot and Rs. 44460/ha in farmer's practice. The cumulative effect of technological interventions over a two year period showed that the average benefit-cost ratio in demonstration plots was 2.00, whereas in farmers' practice it was 1.74.

Keywords: Pink bollworm, *pectinophora gossypiella*, Integrated Pest Management, biological control, chemical control, Bt cotton, pheromone disruption, pest resistance and sustainable agriculture

Introduction

Cotton (*Gossypium* spp.), a “friendly fiber” is one of the most important commercial crops that are cultivated all over the world. Cotton is one of world’s most essential fiber crops having global importance, cultivated in tropical and subtropical regions of more than 70 countries (Shaheen, 2012) [13]. Global 2019-20 cotton area, production and productivity are projected at 34.50 million hectares (85.50 million acres), 121.50 million bales and 791 Kg/ha, which were nearly 4 and 6 percent greater than that of 2018-19. India is the largest cotton producer in the world with 28.50 million bales compared to 26.50 million bales in previous year followed by China (27.25 million bales), United States (20.02 million bales), Brazil (12.00 million bales) and Pakistan (8.00 million bales) (AMIC 2020). As on 26th September 2019, area under cotton during 2019-20 was 127.67 lakh ha as against 121.05 lakh ha in 2018-19 i.e. 5.46 per cent more than the previous year. Among the states, Maharashtra was reported as leading state in cotton acreage (44.05 lakh ha) followed by Gujarat (26.66 lakh ha),

Telangana (18.59 lakh ha), Haryana (7.01 lakh ha) and Rajasthan (6.44 lakh ha) (AMIC 2020). The crop is globally struck by 1326 species of insect pests, out of which 130 different species of insects and mites found to devour cotton at different stages of crop growth in India. (Parmar and Patel, 2016) [11]. Among the bollworms, pink bollworm assumed major pest status in recent past (Ghosh, 2001) [4]. The pink bollworm larvae burrow through lint, penetrating deeply into the immature seeds and consume them. When one seed is destroyed, the larva tunnels through the developing lint to another seed until the locule is destroyed. The affected bolls subsequently rot and are shed, while those that are retained on plants open prematurely resulting in stained, immature fiber (Agarwal *et al.*, 1984) [1]. Worldwide, pink bollworm *Pectinophora gossypiella* (Saunders) has become economically the most notorious pest of cotton and has known to cause 2.8 to 61.9 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) [12]. Costly chemical tactics has resulted

in economic calamity, destruction of natural enemies and environmental hazards (Ayaz *et al.* 2020) ^[3].

Distribution and origin

The pink bollworm, *Pectinophora gossypiella* (Saunders) was described by W.W. Saunders in 1843 as *Depressaria gossypiella* from specimens found to be damaging cotton in India in 1842 (Ingram 1994) ^[6]. Around 1911 and 1913, it reached the Western hemisphere in cotton seed shipped from Egypt to Brazil, Mexico, West Indies and the Philippine Islands. It is generally believed that the insect reached Egypt in damaged cotton seed from India about 1906-1907. Damage was reported in East Arizona in 1926 and later in other parts of the state. In short it can be quoted that pink boll worm is distributed across all cotton growing regions. Pink bollworm is distributed throughout tropical America, Africa, Asia, Australia, Asia, including subtropical regions, Pakistan, Egypt and Mexico. It has been eradicated from all cotton-producing areas of the continental USA (USDA, 2018) ^[15].

Materials and Methods

The Frontline Demonstration (FLDs) were conducted by Krishi Vigyan Kendra, Khamgaon Beed-II, on farmers' fields in the village of Khamgaon Tq. Georai & Dist. Beed in Maharashtra, during the *Kharif* seasons of 2021-22 and 2022-23, to evaluate several approaches for controlling pink bollworms in cotton in farmer's fields. Through pre-kharif awareness programs, targeted group talks, method demonstrations, training programs, sensitization workshops and field days, the farmers were made aware of the importance of these technologies during the sessions. These experimental sites are located in a semi-arid agro-climatic zone with medium-textured soils. The region has a warm tropical climate, receiving approximately 600–700 mm of rainfall annually, mainly during the south-west monsoon season. During the cropping period, average temperatures ranged from 18 to 34 °C.

The trials were conducted across 10 farmers' fields, each with one acre demonstration plot, under typical farming conditions. Two treatments were tested to evaluate the effectiveness of Integrated Management against pink bollworm in cotton. The first treatment (T₁) involved farmers' traditional pest control methods, which used acephate 1.5 g/ lit, chlorantraniliprole 0.3 ml/ lit, and lambda cyhalothrin 0.5 ml/ lit. per 10 litres of water. The second treatment (T₂) used an improved IPM approach, including the installation of pheromone traps to monitor adult moth activity, followed by azadirachtin 1500 ppm @ 5ml/ lit, quinalphos @ 2.5ml/ lit or emamectin benzoate 0.5 g/ lit, thiodicarb @1.5 g/ lit, spinosad @ 0.35 ml/ lit, and spray 1 or 2 times in later stages of the crop cypermethrin @1ml/ lit or lambda cyhalothrin @ 1 ml/ lit. served as an alternative insecticide depending on pest pressure.

Farmers in both the demonstration and the check plots were personally interacted in order to gather data. The purpose of the demonstrations was to examine the yield discrepancy between the farmer's practice and the demonstration plot. The yield statistics from the farmer's practice and demonstration trials were recorded and a random crop cutting experiment was also carried out. The cost of cultivation, net returns, gross returns and benefit-cost ratio

were among the other data characteristics that were noted.

All agronomic practices, except plant protection measures, were kept uniform across both treatments and followed as per the recommended package of practices for cotton. The IPM interventions were initiated immediately after the detection of pink bollworm incidence in the crop.

Results and Discussion

Integrated pest management

The high costs of chemical control, continuing economic losses, secondary pest problems and environmental considerations suggest the need for ecologically oriented pink bollworm management strategies. Extensive research has resulted in a broad array of monitoring, biological control, cultural, mechanical, behavioural, genetic and host plant resistance methods that can serve as a base for the formulation of integrated pink bollworm management systems.

The goal of Integrated Pest Management (IPM) is to control pest populations in a way that is both economically and environmentally sustainable. One of the key components of IPM is monitoring, which comprises regular observation of pest populations to determine the presence and quantity of pests, such as the pink bollworm, in the field. Instead of using pesticides at random, this enables farmers to make well informed decisions based on real-time data (Kranthi, 2015) ^[8]. Another crucial element is threshold levels, or the density of pests at which control measures are necessary. By establishing these thresholds, farmers can avoid using unnecessary pesticides when pest populations are below ETL levels. The final step in integrated pest management (IPM) is the selection of appropriate control methods, which can include cultural practices like crop rotation, mechanical methods like destroying agricultural leftovers and biological controls like parasitoids or predators (Sundararaj and Ramasubramanian, 2023) ^[14].

Cultural control measures

Cultural control methods, which are often considered the first line of defense against pink bollworm infestations, include crop rotation, post-harvest, crop residue removal, and timing of planting and harvesting. Crop rotation has been one of the most effective cultural strategies.

Crop rotation has been one of the most effective cultural strategies. switching cotton with non-host crops, you can disrupt the pink bollworm's life cycle and reduce its ability to establish a stable population. However, the efficacy of this strategy is often limited by local agricultural practices; in many places, cotton is grown continuously, making rotation less feasible (Gunderson and Simmel, 2021) ^[5]. Destroying crop remnants after harvest is another frequently recommended practice. Cotton stalks must be ploughed or shredded to eliminate the larvae that overwinter in the plant debris and prevent the pest from surviving between cropping seasons. When combined with early planting and harvesting, which shortens the window of exposure to pink bollworm infestation, these techniques can significantly limit the impact of the pest (Jayaraj and Muthukrishnan, 2021) ^[7].

Mechanical and Physical Control Measures

Managing and controlling pests with methods like collection

of adult insects with nets, removal of rosette flowers and infested bolls, installation of pheromone traps @ 10/ac are known as mechanical control. In order to control pests, weeding and temperature changes are also included. Farmers are looking for sustainable methods to control pests without harming the environment.

Biological Control Measures

Chemical treatments are becoming less effective due to environmental concerns and resistance, biological management strategies are now essential for controlling pink bollworm in cotton fields. Beneficial insects such as parasitoid, particularly *Trichogramma* species, are among the most significant biological control agents. These small wasps parasitize and finally kill the host insect eggs by laying their eggs within the eggs of the pink bollworm. These natural enemies have actually been effectively employed in integrated pest management (IPM) programs in some cotton-growing areas to decrease the need for chemical treatments, particularly when paired with other control techniques (Gunderson and Simmel, 2021) ^[5]. By using these biological control agents, it leads to more sustainable pest management (Sundararaj and Ramasubramanian, 2023) ^[14].

Chemical Control Measures

If trap catches exceed 8-10 adults / day for 3 consecutive days / if 10% rosette flowers or 10% damaged green bolls are observed then the schedule of sprays as below followed

rotating the chemicals on need basis- a) azadirachtin 1500 ppm @ 5ml/ lit with surf (1g), quinalphos @ 2.5ml/ lit or emamectin benzoate 0.5 g/ lit; thiodicarb @1.5 g/ lit; spinosad @ 0.35 ml/ lit; and spray 1 or 2 times in later stages of the crop cypermethrin @1ml/ lit or lambda cyhalothrin @ 1 ml/ lit. Farmer's practice includes spraying of insecticides like acephate 1.5 g/ lit, chlorantraniliprole 0.3 ml/ lit, and lambda cyhalothrin 0.5 ml/ lit.

The economic metrics, including net returns, gross returns and the B:C ratio, were displayed in Table 1. The figures show that the gross returns, net returns and BC ratio of the demonstration plots were much higher than farmers' practices throughout the course of the two years of demonstration. In farmer practice, the average gross returns were Rs. 61,200/ha, whereas in demonstration practice, it was Rs. 83,366/ha. In Demonstrative practice net returns generated is Rs. 46587/ha, while in farmers' practice it is Rs. 32578/ha. The average cost of cultivation during the study period was Rs. 46175/ha in the demonstration plot and Rs. 44460/ha in farmer's practice. The cumulative effect of technological interventions over a two year period showed that the average benefit-cost ratio in demonstration plots was 2.00, whereas in farmers' practice it was 1.74. The results are consistent with those of Narendar *et al.*, 2021 ^[10] who discovered that Demo farmers had greater B:C ratios and net returns. Similar results were reported by Kolhe *et al.*, 2017 ^[9] who noted that the incidence of pink bollworms was low in demonstration plot.

Table 1: Economics

Year	Area (Acre)	Trial	Yield q/ha			Cost of cultivation		Gross return		Net return		B:C Ratio	
			Demo	Check	% Increase	Demo	Check	Demo	Check	Demo	Check	Demo	Check
2021-22	10	10	15	13.10	14.50	45250	43120	85890	75010	42770	29760	1.89	1.73
2022-23	10	10	13	11.25	15.55	47100	45800	95604	82497	50404	35397	2.11	1.75
Average	10	10	14	12.17	15.02	46175	44460	90747	78753	46587	32578	2.00	1.74

Conclusion

The adoption of Integrated pest management technology on pink bollworm in *Bt* cotton show that the gross returns, net returns and BC ratio of the demonstration plots were much higher than farmers' practices throughout the course of the two years of demonstration. The incidence and damage of pink bollworm was low in demonstration plots because of the use of Integrated Pest Management technologies, such as the identification of pests and damage symptoms at the field level, regular pest monitoring through field visits and recommendations periodically provided by KVK, Khamgaon scientists. Farmers were able to understand the purpose and importance of pest monitoring, the concept of ETL and need-based pesticide application. The incidence was high in farmers' practices because they were unaware of new technology and did not adopt IPM methods. The IPM strategy led to higher profits. Therefore, adopting IPM is recommended for effective, cost-efficient, and safe management of pink bollworm in cotton.

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