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SPECIALIZED PHEROMONE AND LURE APPLICATION TECHNOLOGY (SPLAT) FOR MANAGEMENT OF PINK BOLLWORM IN COTTON: A NATURE-FRIENDLY TOOL

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ABSTRACT

ICAR-Krishi Vigyan Kendra's, Dharwad conducted 20 frontline demonstration on Mating Disruption Technique (SPLAT) for management of pink bollworm (*Pectinophora gossypiella*) in Cotton during kharif season of 2022-23 and 2023-24 at farmers' field to transfer the technology and knowledge level in farming community of Dharwad district through Trainings and other extension activities. The results showed that SPLAT pheromone treated field recorded average lowest per cent of rosette flower of 10.32, green boll damage of 8.75 and locule damage of 9.89 compared with farmers practice. Similarly, SPLAT treated plot recorded higher seed cotton yield of 18.72 and 22.2 q/ha with higher net return profit of Rs 95825 and 134648 rupees during the respective years and found superior over farmers practice. The disparity in technology, the extension deficit, and the technology index within the demonstration field varied between -0.02 to 12.48, 1.4 to 5.8, and -0.08 to 43.11%, respectively. A lower technology index (-0.08) in the study region suggests a higher technological viability under real-world farming conditions.
***Keywords*:** SPLAT, Cotton, Pink bollworm, Demonstration and Farmers practice.

Introduction

Cotton (*Gossypium hirsutum* L.), the "King of Apparel Fiber" and "White Gold," holds an unparalleled position in India's agricultural economy and cultural heritage. India, the global leader in cotton cultivation, accounts for 129 lakh hectares, yielding 26.30 million bales annually with a mean productivity of 443 kg/ha (Foreign Agricultural Services, 2024). However, cotton production is severely hampered by approximately 160 insect pests, particularly sucking pests and the bollworm complex, which inflict yield losses of up to 60% (Ayyar 1932; Ingram 1981; Puri *et al.*, 1999; Dhaliwal *et al.*, 2004).

The introduction of genetically modified cotton (*Bt cotton*) BG-I in 2002 and BG-II in 2006 marked a transformative phase in India's cotton production landscape, leading to a substantial expansion in cultivated areas (Qaim, 2020). *Bt* cotton, genetically engineered to synthesize insecticidal proteins derived from the bacterium *Bacillus thuringiensis* (Bt), has redefined pest management strategies, particularly for the lepidopteran borer pest complex (Kranthi, 2015). Its introduction in India aimed to enhance productivity, elevate profitability, mitigate damage from destructive pests, and reduce farmers' dependence on conventional chemical insecticides (Choudhary and Gaur, 2013). Despite its widespread adoption and significant contributions to pest control and yield improvement, challenges persist in the sustainability of *Bt cotton* production (Naik *et al.*, 2020).

The pink bollworm, *Pectinophora gossypiella* (Saunders) (Lepidoptera: Gelechiidae), ranks among the most economically devastating insect pests of cotton globally (Tabashnik *et al.*, 2000; Naik *et al.*, 2018). This pest inflicts damage on up to 55% of cotton locules, leading to a significant decline in seed cotton yield ranging from 35% to 90% (Naik *et al.*, 2021). The larvae's internal feeding behavior undermines the efficacy of insecticidal applications and exacerbates resistance development across multiple pesticide groups, rendering chemical control prohibitively expensive and unsustainable.

Recognizing the limitations of current control methods, there is a growing need for eco-friendly, mating disruption (Attique *et al.*, 2000; Athanassiou *et al.*, 2002) and cost-effective alternatives that require less labor. In response to this demand, SPLAT-PBW, a novel mating disruption formulation, was developed and evaluated for its effectiveness in managing pink bollworm infestations. Keeping in this view a frontline demonstration was conducted by ICAR Krishi Vigyan Kendra, Dharwad in a farmer's field aimed to determine the effectiveness of SPLAT-PBW at Dharwad district of Karntaka, India and assess its effectiveness compared to farmer's practices.

Materials and Methods

Frontline Demonstration at farmer's field:

Cotton growing farmers were selected from ICAR-KVK Dharwad operational area based on participatory rural appraisal by KVK scientist for executing. Scientists were explained about the SPLAT technology and its application to manage the PBW. It was advised not to use the insecticides in the SPLAT pheromone-treated plots. Frontline demonstrations were carried out in two sequential years i.e., 2022-23 and 2023-24 during *Kharif* season at Annigeri, Inglahalli, Haro Belavadi and Byalyal villages of Dharwad district of Karnataka state, India. Demonstration were conducted in 16 ha area of 20 selected farmers field at said villages, it aims to improve the knowledge level on pink boll worm identification, damaging symptoms and management practices in cotton through frontline demonstration, method demonstration of SPLAT application and provided training on pink bollworm management. Each frontline demonstration was laid out in 0.4 ha area which was taken as demo while an adjacent 0.4 ha was taken as a control for comparison of farmer's practice. Jadoo and MRCH-7383 (BG-II) a popular Bt cotton hybrid, was planted by most farmers during the second week of June 2022 and 2023 *Kharif*. In general, soils of the area under study were black soil with the average annual rainfall of this area is 787 mm. The details of demonstrated and control plot was given in Table 1.

Table 1 : The technology was demonstrated in selected farmer's field:

S.No	Demonstrated technology	Check (Farmers practice)
1.	SPLAT was demonstrated in with dosage of 500 g/acre and applied three times equally at 65-70 followed by 95-100 and 125-130 days after planting of cotton during 2022-23 and 2023-24 *Kharif* season. Pheromones paste was directly applied with hand to the leaf junction of terminal plant part in the farmers' field.	1.Not installing pheromone traps 2. Spraying of Profenophos 50% EC @ 2ml/l or Lamda Cyalothrin 5% EC @ 1ml/l or Chlorantraniliprole 18.5% SC @ 0.2ml/l and Emamectin benzoate 5 SG @ 0.2 g/l after pest occurrence.

The data on the pink bollworm incidence in demonstration and farmers practice fields were recorded. The observations on rosette flowers due to PBW infestation was started on 25 randomly selected plants from flowering stage to boll development stage. Based on the total number of flowers and number of rosette flowers per plant, was worked out. Similarly, for observation on the green boll damage, 50 bolls of two weeks' old were collected randomly from each block and cut opened. Based on the total number and damaged bolls by pink bollworm, percent green boll damage was worked out. The infestation ratio was determined by counting infected bolls and then represented as a percentage.

$$\text{Per cent infestation} = \frac{\text{Number of fruits damaged}}{\text{Total number of fruits observed}} \text{X } 100$$

$$\text{Per cent increase in yield} = \frac{\text{Demo yield} - \text{Farmers practice yield}}{\text{Farmers practice yield}} \text{X } 100$$

Economics: The economics of the FLD'S and farmer's practice were worked, and qualitative data were converted into quantitative form and expressed in terms of a percent increase in yield (Narasimha *et al.* 2007). Finally, the extension gap, technology gap, technology index, along with benefit-cost ratio were worked out (Samui *et al.* 2000) by applying the following formula:

Technology gap=Potential yield -Demonstration Yield

Extension gap = Demonstration Yield-Farmers yield

$$\textbf{Technology index} = \frac{\text{Potential yield} - \text{Demonstration yield}}{\text{Potential yield}} \text{X } 100$$

To disseminate the information about the demonstration fields on a large scale, regular farmers and KVK, scientist visits were organized.

Results and Discussion

Specialized Pheromone and Lure Application Technology (SPLAT) utilizes a wax-based formulation designed for sustained-release pheromones, effectively disrupting insect pests' mating behaviors and impeding

their reproduction. By simulating the emission of natural female insect pheromones, SPLAT confuses male insects, rendering them unable to locate mates. This disruption leads to a decline in insect pest populations by reducing mating rates (Table 2).

SPLAT technology was implemented in Annigeri, Inglahalli, Harobelavadi and Byalyal villages of Dharwad district as alternative tool for pink bollworm management in *Bt*. Cotton crop during 2022-23 and 2023-24 Kharif season. Observations recorded on per cent rosette flowers, green boll damage and locule damage and results are presented below

Rosette Flowers (%)

Initially PBW damage on flower was noticed during the first fortnight of August 2022 and 2023 kharif, during the consecutive season and increased gradually reaching its peak during September in both the years. After the formation of bolls incidence has declined slowely. Comparative data on percent rosette flower indicated that, SPLAT pheromone treated demonstration field registered low percentage of rosette flower (11.32% and 9.31% with a mean of 10.32%) compared to (22.5% and 21.53% with mean of 22.02%) farmers practice (Fig. 1).

Green boll damage (%)

The green boll damage (%) due to PBW was noticed from the second fortnight of the August and increased gradually with the advancement of cropping seasons. The lowest green boll damage of 9.26 and 8.23 per cent with a mean of 8.75 per cent over the farmers practice (20.25% and 26.12% with mean value of 23.19%) during the consecutive seasons of 2022 and 2023 respectively (Fig. 1).

Locule damage (%)

The observation on locule damage revealed that SPLAT pheromone treated block registered lowest locule damage of 10.25 and 9.52 per cent compared with farmers practice (21.45% and 23.6% with an average of 22.53%) during both season respectively (Fig. 1).

Yield and Cost Economics

SPLAT is a wax-based product that is an eco-friendly alternative to other pest management tools. Mating disruption and Behavioural modifying specialized lure application technology has effectively managed the incidence of PBW which lead to the contribution of higher seed cotton yield during 2022-23 and 2023-24. SPLAT PBW pheromone treated demo plot recorded higher seed cotton yield of 18.72 and 22.2 q/ha with higher net return profit of Rs. 89979 and 134648 rupees during the respective years and found superior over farmers practice (Table 3a and 3b).

The economics of management of PBW by SPLAT technology in Bt Cotton during 2022-23 and 2023-24 was presented in Tables 3a–3b, respectively. The spending on insecticide application was an essential factor in the total cost of cultivation in farmers' practices. The average total cost of production in SPLAT treated plot was Rs. 35800/- and 31815/- with the highest seed cotton yield was 18.72q/ha and 22.20 q/ha during 2022-23 and 2023-24 respectively. Farmers practice was recorded higher cost of production Rs. 36900/- and 34965/- with the lower yield of 15.1q/ha and 16.97q/ha during the said years respectively. The net returns obtained from cotton cultivation on SPLAT applied field were, i.e. Rs. 95247/- and 134648/- higher than farmers practice Rs. 68800/- and 92310/-. The Benefit-cost ratio comparison presented in Tables 3a and 3b shows that SPLAT treated plot gave more benefit cost ratio, *i.e.* 3.63 and 5.24 compared to farmer's practice 2.83, and 3.64 respectively during 2022-23 and 2023-24.

The disparity in technology gap, the extension gap, and the technology index between the frontline demonstration field varied between -0.02 to 12.48, 1.4 to 5.8, and -0.08 to 43.11%, respectively. A lower technology index (-0.08) in the study region suggests a higher technological viability under real-world farming conditions (Fig. 2.).

In this study the influence of specialized pheromone lure application technology is behavior modifying chemical on the incidence of pink bollworm was quite evident. This technology is vary new to the farmers of Dharwad district, Among the frontline demonstration field the data recorded over two seasons clearly indicated that, SPLAT pheromone treated field recorded average lowest per cent of rosette flower of 10.32, green boll damage of 8.75 and locule damage of 9.89 compared with farmers practice. The effective suppression of pink bollworm in SPLAT pheromone treated demo fields during the consecutive seasons, resulted in significant reduction in PBW incidence which contributed towards more number of good opened bolls per plant and higher seed cotton yield of 18.72q/ha and 22.20 q/ha during 2022-23 and 2023-24 respectively. These results are in agreement with Qureshi *et al*, (1988) who observed lower incidence of pink bollworm in flower (0.19%) and green boll damage (1.67%) using PB RopeL @ 200/ha. Also Field testing of SPLAT against pink bollworm for modifying the behavior and mating disruption was conducted previously by many researchers. However, a similar study during 2020 had recorded a reduction of

86.72 %, 62.03 %, and 74.21 % of male moth catch, larval density, and locule damage in green bolls, respectively, with an increase of 16.89 % of seed cotton yield (Mahalakshmi *et al*, 2020; Mafra-Neto *et al*., 2013; Unlu and Mezreli, 2011). Likely, Patil *et al*. (2004) registered lower population of 9.76 and 8.40 larvae/50 bolls in PB Rope @ 200 dispensers per ha as compared to control block (20.48 and 19.40 larvae/50 bolls) during 2005-06 and 2006-07 respectively. Similarly, The effective suppression of pink bollworm in SPLAT pheromone treated block resulted in significant reduction in green boll damage contributed for higher seed cotton yield of 27.68 q/ha compared to recommend plant protection (18.75 q/ha) and untreated blocks (15.30 q/ha). These results corroborated with the findings of Shrinivas *et al*. (2018) who reported higher seed cotton yield of 46.25q/ha in SPLAT treated block compared to 24.55q/ha in farmer's fields. The phenology of male *Proeulia auraria* (Lepidoptera: Tortricidae) was studied in vineyards, apple orchards, and blueberry fields, where the application of a pheromone blend at 78 g/ha effectively disrupted mating across all crops for a duration of five months. These findings indicate that the use of SPALT technology offers a viable approach to managing *P. auraria* populations through mating disruption (Flores *et al*., 2021). The results demonstrated that SPLAT-PBW applied at a rate of 500 g/acre proved optimal, achieving significantly reduced rosette flower incidence (8.23%), green boll damage (7.36%), and locule damage (8.41%). Furthermore, it resulted in a markedly higher yield of 33.59 q/ha, outperforming the conventional farmer's practice, which produced only 22.33 q/ha despite 5–6 rounds of insecticidal applications (Shrinivas *et al*., 2021).

Patil *et al*. (2022) reported an average rosette flower (4.33 and 3.60%), green boll damage (6.22 and 7.13%), open boll damage (7.53 and 7.87%) and locule damage (8.75 and 8.42%) during 2018-19 and 2019-20, respectively was less in SPLAT pheromone treated block as compared to RPP and untreated control block.

The lower technology index shows greater visibility of the advanced technology in farmer's fields (Jeengar *et al.*, 2006). In succeeding years the farmer's carried out demonstration were come out with good results with the trend of technology gap ranging from -0.02 to 12.48. The observed technology gap could be attributable to differences in soil fertility state, soil nutrient enrichment, organic manure, and environmental circumstances, such as rainfall and temperature (Dhandhalya and Shiyani 2009). During study period farmers were expressed their opinion that its eco-friendly, safe for humans, pest specific and cost effective.

Conclusion

Specialized pheromone lure application technology formulations were applied to the source point of the crop. Males have diverted away from females due to the powerful allure of the pheromone being emitted by each SPLAT dollop. Area-wide management of pink bollworm over an area of 16 ha with SPLAT-PBW, a mating disruption tool applied at 500 g m/acre in 3 splits at 65-70 followed by 95-100 and 125-130 days after sowing recorded more than 82–87% control of pink bollworm with maximum yield gain of 22.20q per ha compared to conventional farmers practice who realized 18.72 q per ha under rainfed condition. Technology intervention resulted highest benefit cost ratio (3.63 and 5.24, 2.83, and 3.64) in technology adopted farmers field as compared with farmers practice. A lower technology index (-0.08) in the study region suggests a higher technological viability under real-world farming conditions. The non-chemical approach of pink bollworm management offers significant control over farmer's practices. Hence, under present circumstances, the best way to curb the menace of pink bollworm is insect mating disruption using SPLAT-PBW. From the above findings an interference could be drawn that Front Line demonstrations (FLDs) conducted by ICAR-KVK, Dharwad played an important role in increasing the production of cotton through adopting SPLAT-PBW management technology in the crop.

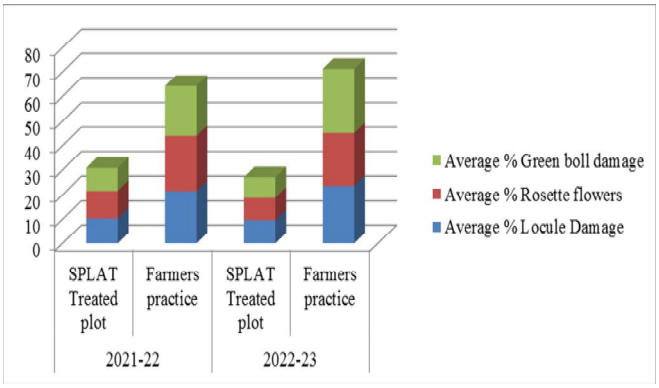

Fig. 1: Per cent damage of pink bollworm on flowers, locule and green boll during 2022-23 and 2023-24.

Table 2 : Level of use and gap in adoption of Pink bollworm management technologies in the study area

S. No	Integrated pest management practices for Pink bollworm in cotton	Level of adoption	
		FLD farmer	Non FLD farmer
1	Installation of Pheromone trap at 40 DAS	Adopted	Non adopted
2	Identification of different boll worms	Adopted	Non Adopted
3	Identification of damaging symptoms of pink boll worms	Adopted	Non Adopted
4	100 DAS application of ovicidal insecticides like profenophos 50 EC @ 2ml/l or spinetoram 12 SC @ 1ml/l	Adopted	Adopted
5	Awareness about SPLAT technology	Adopted	Non Adopted
6	Method and period of SPLAT application	Adopted	Non Adopted
7	Destruction of seeds after ginning	Adopted	Non Adopted
8	Installation of pheromone traps at ginning mill	Adopted	Non Adopted
9	Removal cotton stubbles from the field immidietly after harvesting	Adopted	Non Adopted

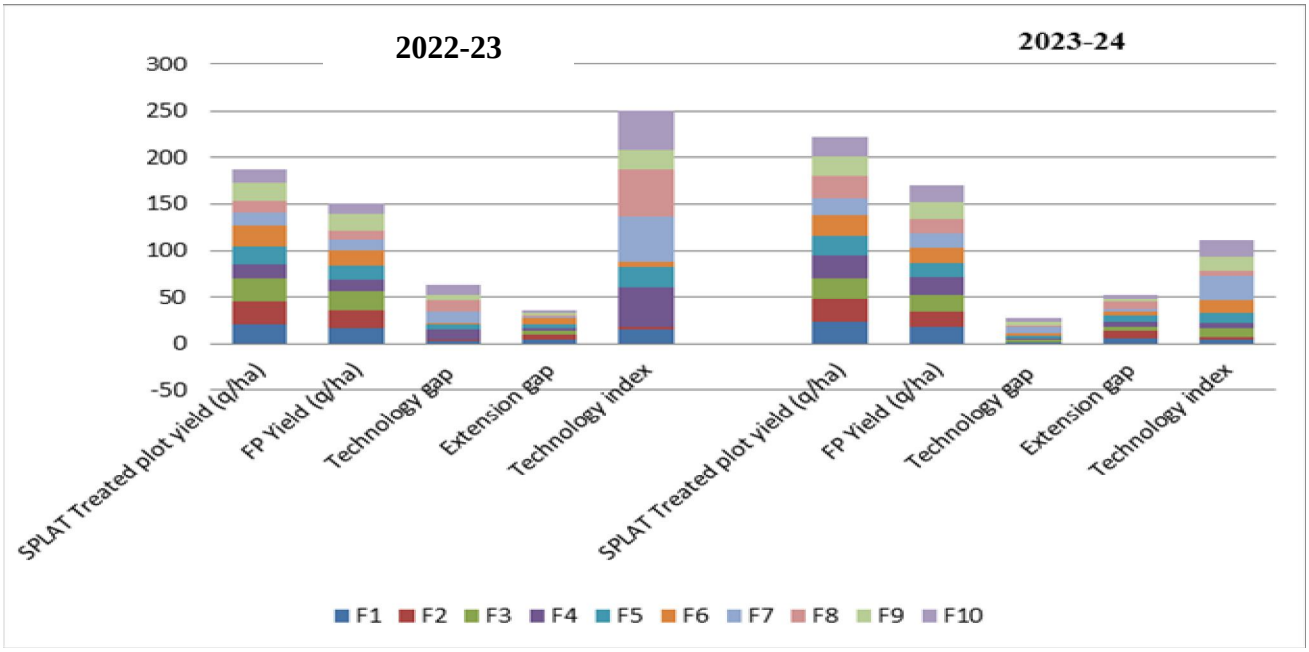

Fig. 2: Yield, extension gap, technology gap, and technology index on pink bollworm management in cotton during 2022-23 and 2023-24.

Table 3a: Yield and cost economics of IPM in pink bollworm during 2022-23

Perticulars	Yield (q/ha)		Gross Cost (Rs./ha)		Gross Return (Rs./ha)		Net Return (Rs./ha)		BC ratio		% increase in Yield
	SPLAT Treated plot	Farmers practice	SPLAT Treated plot	Farmers practice	SPLAT Treated plot	Farmers practice	SPLAT Treated plot	Farmers practice	SPLAT Treated plot	Farmers practice	
F1	21.25	16.2	35600	38900	148750	113400	113150	74500	4.18	2.92	31.17
F2	24.2	19.2	33500	40450	169400	134400	135900	93950	5.06	3.32	26.04
F3	25	20.5	42500	42450	175000	143500	132500	101050	4.12	3.38	21.95
F4	14.45	12.3	35450	35430	101150	86100	65700	50670	2.85	2.43	17.48
F5	19.6	15	35200	35230	137200	105000	102000	69770	3.90	2.98	30.67
F6	23.4	17.6	41550	41550	163800	123200	122250	81650	3.94	2.97	32.95
F7	12.6	11.2	33750	33730	88200	78400	54450	44670	2.61	2.32	12.50
F8	12.5	10.25	30100	30100	87500	71750	57400	41650	2.91	2.38	21.95
F9	20	17.5	38750	38658	140000	122500	101250	83842	3.61	3.17	14.29
F10	14.21	11.25	31600	32500	99470	78750	67870	46250	3.15	2.42	26.31
Average	**18.72**	**15.1**	**35800**	**36900**	**131047**	**105700**	**95247**	**68800**	**3.63**	**2.83**	**23.53**
Max	25	20.5	42500	42450	175000	143500	135900	101050	5.056716	3.380448	-
Min	12.5	10.25	30100	30100	87500	71750	54450	41650	2.613333	2.32434	-

Table 3b: Yield and cost economics of IPM in pink bollworm during 2023-24

Perticulars	Yield (q)		Gross Cost (Rs/ha)		Gross Return (Rs./ha)		Net Return (Rs./ha)		BC ratio		% increase in Yield
	SPLAT Treated plot	Farmers practice	SPLAT Treated plot	Farmers practice	SPLAT Treated plot	Farmers practice	SPLAT Treated plot	Farmers practice	SPLAT Treated plot	Farmers practice	
F1	23.8	18.1	32000	35750	178500	135750	146500	100000	5.578	3.797	31.49
F2	24.5	16.6	31000	33850	183750	124500	152750	90650	5.927	3.678	47.59
F3	22.3	17.9	32000	34900	167250	134250	135250	99350	5.227	3.847	24.58
F4	23.65	18.25	31250	36800	177375	136875	146125	100075	5.676	3.719	29.59
F5	22.25	15.5	31750	35600	166875	116250	135125	80650	5.256	3.265	43.55
F6	21.8	16.8	32600	35500	163500	126000	130900	90500	5.015	3.549	29.76
F7	18.5	16.5	31500	34900	138750	123750	107250	88850	4.405	3.546	12.12
F8	23.4	15.25	31650	34850	175500	114375	143850	79525	5.545	3.282	53.44
F9	21.25	17.7	31750	33000	159375	132750	127625	99750	5.02	4.023	20.06
F10	20.5	17.1	32650	34500	153750	128250	121100	93750	4.709	3.717	19.88
Average	**22.20**	**16.97**	**31815**	**34965**	**166463**	**127275**	**134648**	**92310**	**5.24**	**3.64**	**30.79**
Max	24.5	18.25	32650	36800	183750	136875	152750	100075	5.927419	4.022727	
Min	18.5	15.25	31000	33000	138750	114375	107250	79525	4.404762	3.265449	

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