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# Demonstration and Adoption of Integrated Pest Management Strategies for the Management of Pink Bollworm *Pectinophora gossypiella* (Saunders) in Cotton

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## ABSTRACT

The present study was carried out in the farmers' fields of Bhadradri Kothagudem, Telangana, India during *Kharif* (June–December) seasons of 2018, 2019 and 2020 to demonstrate the integrated pest management strategies for the management of pink bollworm and to know its rate of adoption among the farming community. The treatments consisted of technology demonstration and farmers' practice. During three years of study, the population of pink bollworm has showed increasing trends. More than 10% of the rosette flowers were observed during the crop period starting from 36th SMW and continued up to 48th SMW. The green boll damage caused by PBW ranged between 2.1–19.2 in the demo plot, while the range was 2.2–20.6 in the control. Average population in pheromone traps was 4.48, 5.31 and 5.34 trap$^{-1}$ during 2018, 2019 and 2020 respectively. Standard weeks 36–38 (3rd September–23rd September) 51–3 (17th December–21st January) were minimum or no activity periods due to low temperature, while standard weeks, 40–44 (1st October–4th November) were high activity periods during these study years. The population of pheromone traps correlated with temperature and rainfall had shown negative and non-significant correlation during 2018 and 2020, while positive and non-significant correlation during 2019. Cotton seed yield in the technology demonstrated plot was higher (1965, 2055 and 2095 kg ha$^{-1}$) compared to farmers practice (1607, 1708 and 1725 kg ha$^{-1}$) during 2018, 2019 and 2020 respectively. By adopting the IPM strategies against this pest, farmers' can avoid the yield losses up to 22.3%. Nearly 65% of the respondents had medium level of adoption on management practices for the control of PBW.

**KEYWORDS:** adoption, Cotton, income, locule, management, pink bollworm, rosette

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***Data Availability Statement:*** Legal restrictions are imposed on the public sharing of raw data. However, authors have full right to transfer or share the data in raw form upon request subject to either meeting the conditions of the original consents and the original research study. Further, access of data needs to meet whether the user complies with the ethical and legal obligations as data controllers to allow for secondary use of the data outside of the original study.

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## 1. INTRODUCTION

Cotton (*Gossypium hirsutum* L.) is the most important fibre crop grown in India. It is commonly known as the "King of fibres" or "White gold". India is one of the largest producers of cotton in the world accounting for about 26% of the world cotton production. Currently Bt hybrids are grown in 13,061 lakh ha with production of 34,347 lakh bales (Mishra et al., 2023). The productivity of cotton i.e. 447 kg ha$^{-1}$ is lower against the world average yield of 768 kg ha$^{-1}$ (Anonymous, 2023). There are many factors which hinder the production of cotton, mainly biotic and abiotic stresses (Hussain et al., 2023). Among various biotic factors responsible for low yield, the losses caused by insect pests are of major importance. The insect pest spectrum of cotton is quite complex and as many as 1326 species of insect pests have been reported on this crop throughout the world (Abbas et al., 2022). Bollworms alone are known to cause 50% yield loss in cotton (Mahalakshmi and Prasad, 2020). Among them, the pink bollworm (PBW), *Pectinophora gossypiella* (Saunders) (Lepidoptera: Gelechiidae), is one of the primary factors contributing to the lowest yield of cotton in India. PBW originated in the Indo-Pak region and is distributed worldwide wherever cotton is grown. It damages squares and cotton bolls. Larvae enter the bolls and feed on the seeds. As the larva bores inside the boll, the lint is cut and tied, resulting in a significant loss of cotton quality. The pest completes four generations on cotton crop and the fifth-generation rests on the left-over bolls on the cotton sticks and the bolls in the ginning factories (Hussain et al., 2021). Unlu and Bilgic (2004) reported that 1% increase in the infestation rate of PBW caused a 2.5–6.0% yield loss of cotton. The Pink bollworm, once a serious problem for non *Bt* Cotton especially in the later stage of the crop has now become a major problem in *Bt* Cotton hybrids appearing from the flowering stage of the crop and inflicting damage if unattended (Likhitha et al., 2023).

Change in climatic factors may increase or decrease insect population in the field. Abrupt change in weather conditions may be the constant progression of pests in such a way that make pests adaptive to current prevailing conditions, which severely affected the cotton productivity in term of quantity and quality (Shrestha, 2019). So there is a dire need to manage the pest on priority basis.

To manage the pink bollworm and other pests on cotton in India, synthetic pyrethroids and broad-spectrum insecticides were commonly used. However, the extensive use of chemical insecticides led to ecological disruption, causing outbreaks of bollworm and secondary pests. PBW is a major problem in India, primarily because of long duration varieties and the absence of any potent control measures (Dhurua and Gujar, 2011). The simplest and most potent way to overcome the problem is to take up timely sowing and cultivate early maturing varieties of about 150 days duration (Patel et al., 2017). In the Bhadradri Kothagudem district of Telangana, cotton is the predominant crop grown by the tribal population. They are unable to diagnose the pest and assess the damage potential caused by it. Hence the present study was planned to demonstrate the integrated pest management strategies and to create awareness in the control of pink bollworm in cotton.

## 2. MATERIALS AND METHODS

### *2.1. Study site and year of experimentation*

The study was carried out in the farmers' fields of Bhadradri Kothagudem, Telangana, India during *kharif* (June–December) seasons of 2018, 2019 and 2020. Ten farmers' fields were selected for three years in medium black soils under cotton–summer pulse cropping system. The farmers areas were visited in intensive cotton growing areas of 20 different mandals of Bhadradri Kothagudem district. PBW infestation was collected by zig-zag method of pest scouting from 50 locations of those 20 mandals and selected 10 locations for the experimentation. The farmers have sown Mahyco MRC 7376 BG II hybrid during July second fortnight of the year by adopting a planting distance of 90×60 cm$^2$. Standard agronomic practices were adopted to raise the crop (Table 1).

### *2.2. Pheromone trap catches*

To monitor the moth activity of pink bollworm during the cropping period, gossyplure pheromone baited traps @ 8 were installed in one acre area. Each trap was separated 40 m apart and were installed 1.25–1.50 m above the ground on the bamboo sticks depending on the crop stage starting from first week of September 2018 to the end of January 2021. Pheromone lures were procured from pheromone chemicals Pvt.Ltd, Hyderabad and lures were changed after every 21 days. Catches of adult moths were recorded on daily basis. To know the effect of weather parameters, rainfall, morning, and evening RH (%), maximum and minimum temperature data were collected from CPO office of Bhadradri Kothagudem. If pheromone trap catches exceed 8 day$^{-1}$ for 3 consecutive days or if 10% rosette flowers or 10% damaged green bolls are observed in the crop then, the following sprayings were undertaken by rotating the chemicals on need basis. Azadirachtin (0.03%) @ 500 ml ha$^{-1}$, Emamectin benzoate 5% SG @ 250 g ha$^{-1}$, Thiodicarb 75 WP @ 750 ml ha$^{-1}$, Spinosad 45% SC @ 190 ml ha$^{-1}$, Chlorantraniliprole 18.5% SC @ 150 ml ha$^{-1}$ and λ cyhalothrin 5% EC @ 250 ml ha$^{-1}$ at seven days intervals. During the crop period, only one spray of λ cyhalothrin 5% EC @ 250 ml ha$^{-1}$ was taken up by the farmers during the flowering stage.

Table 1: Details of the Demonstrated Technology Vs. Check in Bhadradri Kothagudem, Telangana

| Technology Demonstration | Farmers Practice |
|---|---|
| 1) Deep summer ploughing followed by timely sowing<br>2) Installation of Pheromone traps @ 8 $ac^{-1}$ from 45 DAS and continue them till the last picking/ end of the crop period. Change lures of traps at every 21 days intervals.<br>3) If pheromone trap catches exceed 8 $day^{-1}$ for 3 consecutive days or if 10% rosette flowers or 10% damaged green bolls are observed in the crop then, follow the schedule of sprayings as below by rotating the chemicals on a need basis.<br>a) Azadirachtin (0.03%) @ 500 ml $ha^{-1}$<br>b) Emamectin benzoate 5% SG @ 250 g $ha^{-1}$<br>c) Thiodicarb 75 WP @ 750 ml $ha^{-1}$<br>d) Spinosad 45% SC @ 190 ml $ha^{-1}$<br>e) Chlorantraniliprole 18.5% SC @ 150 ml $ha^{-1}$<br>f) λ cyhalothrin 5% EC @ 250 ml $ha^{-1}$<br>(1 or 2 times in later stages of the crop)<br>4) Collection and destruction of Rosette flowers<br>5) Termination of the crop by the end of December | 1) Non adoption of IPM practices<br>2) Spraying of insecticides i.e. Acephate 75 SP @ 750 g $ha^{-1}$, Chlorantraniliprole 18.5% SC @ 150 ml $ha^{-1}$, λ cyhalothrin 5% EC @ 250 ml $ha^{-1}$ (Farmers practice) |

*2.3. Field incidence of the pest*

Cotton fruiting bodies were sampled at weekly intervals to investigate the association between pheromone trap catches and field incidence of pink bollworm. Ten green bolls were randomly selected from the experimental plot for this purpose. By destructive sampling of green bolls, boll damage % and larvae of PBW were recorded.

*2.3.1. Per cent rosette flowers plant$^{-1}$*

At the time of flowering, number of healthy and rosette flowers were counted from ten randomly selected plants. Based on this, per cent rosette flower per plant were worked out by

Per cent rosette flower=(Number of rosette flowers/Total healthy flowers)×100

*2.3.2. Percent green boll damage*

The number of healthy and damaged bolls by pink bollworm were counted on randomly selected ten plants and the following formula was used to calculate the per cent green boll damage.

Per cent green boll damage=(Number of damaged green bolls/Total number of green bolls)×100

*2.3.4. Number of larvae / 50 green bolls*

50 green bolls were chosen at random from the plot and dissected them and counted the number of larvae per 50 bolls.

Per cent larval population=(Number of larvae in green bolls/ Total number of green bolls)×100

*2.3.5. Per cent green boll damage*

At the time of each picking, number of healthy and damaged bolls were recorded from ten randomly selected plants from the plot. Percent green boll damage was worked out by the formula.

Per cent green boll damage (%)=(Number of damaged green bolls/ Total number of green bolls)×100

*2.3.6. Per cent green locule damage*

At the time of each picking, number of healthy and damaged locules were counted from ten randomly selected plants from the plot. Percent locule damage was worked out by the following formula.

Per cent green locule damage (%)=(Number of damaged locules/ Total number of locules)×100

*2.4. Influence of weather factors on the buildup of pink bollworm*

Counts of male moths collected in the traps were pooled standard week wise and statistically correlated with weather parameters *viz.*, maximum temperature, minimum temperature, average temperature, rainfall, morning, and evening relative humidity by using OPSTAT statistical package.

*2.5. Seed cotton yield*

The weight of cotton seed cotton (kg $ha^{-1}$) from technology demonstrated and control plot were recorded during each picking and later converted to kg $hectare^{-1}$. Avoidable yield loss was calculated by using the formula given by Pradhan (1964).

Avoidable yield loss=((Yield of protected crop−Yield of unprotected crop)/Yield of unprotected crop)×100

*2.6. Rate of adoption*

After the study, the Bt cotton growers were interviewed with the help of structured interview schedule personally. Total 100 respondents were selected for research purpose. The interview schedule was constructed by relevant questions

in accordance with the objective of study. The data were analysed by using mean, S.D. and co-efficient of correlation methods were used for analysis of the data.

## 3. RESULTS AND DISCUSSION

### *3.1. Seasonal incidence of PBW*

#### *3.1.1. Per cent rosette flowers*

The results of the study indicate that more than 10% of the rosette flowers were observed during the crop period starting from 36th SMW (3rd September–9th September) and continued up to 48th SMW (26th November–2nd December) with a seasonal mean of 11.39% rosette flowers. The highest number of 17.82 rosette flowers were observed during 38th SMW (17th September–23rd September). While in control, per cent rosette flowers ranged between 2.0–26.12, with a seasonal mean of 15.53% (Table 2).

#### *3.1.2. Number of larvae 50 bolls$^{-1}$*

PBW larvae per 50 bolls ranged between 3.8–18.8 and 1.21–25.6 with a seasonal mean of 12.13% and 16.41% in the technology demonstrated plot and farmers practice respectively.

#### *3.1.3. Per cent green boll damage*

The green boll damage caused by PBW ranged between 2.1–19.2 in the demo plot, while the range was 2.2–20.6 in the control. The highest green boll damage was observed during 47th SMW i.e. 19th November–25th November. The seasonal mean of green boll damage recorded was 12.6% and 14.24% in the treatment and control respectively.

#### *3.1.4. Per cent green locule damage*

PBW damage to green locules ranged from 2.0–28.4 and 2.0–36.4 in the demo and control plot with a seasonal mean of 7.05 and 9.32 respectively (Table 2). These results are in concurrence with Swaroopa Reddy et al., 2002, who stated that the green boll damage caused by pink bollworm ranged between 20% and 90% with a mean of 26.52%. The Green locule damage caused by pink bollworm ranged

Table 2: Seasonal Incidence of Pink bollworm on cotton crop

| SMW No. | Duration | Rosette flower (%) | | Number of larvae 50 bolls$^{-1}$ | | Green boll damage (%) | | Green locule damage (%) | |
|---|---|---|---|---|---|---|---|---|---|
| | | Demo | FP | Demo | FP | Demo | FP | Demo | FP |
| 36 | Sep 3–Sep 9 | 14.62 | 18.21 | 8.4 | 18.4 | 8.9 | 13.9 | 4.5 | 6.8 |
| 37 | Sep 10–Sep 16 | 15.25 | 20.21 | 8.8 | 18.6 | 9.2 | 15.2 | 3.2 | 5.2 |
| 38 | Sep 17–Sep 23 | 17.82 | 19.26 | 9.8 | 15.6 | 10.6 | 12.6 | 3.5 | 6.2 |
| 39 | Sep 24–Sep 30 | 17.65 | 24.26 | 10.2 | 14.8 | 12.8 | 14.2 | 4.2 | 5.8 |
| 40 | Oct 1–Oct 7 | 16.02 | 23.21 | 15.6 | 25.6 | 16.4 | 19.8 | 5.1 | 5.9 |
| 41 | Oct 8–Oct 14 | 17.18 | 22.21 | 18.2 | 24.4 | 18.2 | 19.2 | 4.6 | 5.2 |
| 42 | Oct 15–Oct 21 | 16.12 | 25.69 | 18.8 | 22.8 | 17.8 | 19.6 | 6.8 | 7.6 |
| 43 | Oct 22–Oct 28 | 15.92 | 26.12 | 18.2 | 20.4 | 18.6 | 20.6 | 7.2 | 7.9 |
| 44 | Oct 29–Nov 4 | 16.84 | 16.84 | 15.2 | 22.2 | 14.8 | 19.5 | 8.2 | 9.2 |
| 45 | Nov 5–Nov 11 | 15.21 | 18.83 | 14.8 | 23.8 | 15.2 | 20.2 | 8.5 | 9.7 |
| 46 | Nov 12–Nov 18 | 13.89 | 15.92 | 14.5 | 22.6 | 18.6 | 19.5 | 9.2 | 10.2 |
| 47 | Nov 19–Nov 25 | 13.01 | 16.85 | 15.6 | 25.2 | 19.2 | 20.6 | 10.2 | 13.4 |
| 48 | Nov 26–Dec 2 | 10.21 | 15.92 | 12.8 | 20.4 | 16.8 | 18.5 | 12.5 | 18.2 |
| 49 | Dec 3–Dec 9 | 6.21 | 16.58 | 14.2 | 22.5 | 18.2 | 20.2 | 28.4 | 36.2 |
| 50 | Dec 10–Dec 16 | 8.12 | 10.21 | 22.6 | 22.2 | 14.4 | 14.8 | 12.2 | 22.4 |
| 51 | Dec 17–Dec 23 | 6.15 | 8.12 | 10.0 | 4.21 | 8.5 | 8.8 | 6.5 | 8.2 |
| 52 | Dec 24–Dec 31 | 4.21 | 6.02 | 6.2 | 3.24 | 6.2 | 5.3 | 4.2 | 6.3 |
| 1 | Jan 01–Jan 07 | 2.21 | 4.21 | 4.8 | 1.21 | 5.4 | 2.2 | 2.0 | 2.0 |
| 2 | Jan 08–Jan 14 | 1.25 | 2.0 | 3.8 | 0 | 2.1 | 0 | 0 | 0 |
| 3 | Jan 15–Jan 21 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Mean | 11.39 | 15.53 | 12.13 | 16.41 | 12.60 | 14.24 | 7.05 | 9.32 |
| | SD± | 6.02 | 8.02 | 13.02 | 15.01 | 10.96 | 14.96 | 7.12 | 13.21 |

between 12.5% and 68.5% with a mean of 17.65%. The population of pink bollworm larvae per 10 green bolls ranged between 2 to 14 with a mean of 3.13 larvae per 10 green bolls. Manisha et al., 2023 recorded that PBW damage in green fruiting bodies was recorded the lowest (0.67 and 3.67%) in chemically protected plot compared to unprotected plot (1.33 and 5.00%) during 2018 and 2019 respectively. Sasikumar and Vimala, 2020 revealed that spinosad (45% SC) @ 250 ml ha$^{-1}$ was most effective against PBW infestation followed by chlorantraniliprole (18.55 SC) @ 150 ml ha$^{-1}$ by recording the lowest rosette flower incidence, larval population 20 bolls$^{-1}$ and locule damage at harvest. While Lakshmanna et al., 2020 reported that during the normal sowing (20$^{th}$ July) the incidence of PBW ranged from 0.03–0.35 larvae 20 bolls$^{-1}$, whereas in delayed sowing, the PBW ranged from 0.00–0.33 larvae 20 bolls$^{-1}$. Though there was no significant difference between the treatments with respect to incidence levels of PBW, the higher number of PBW larvae were recorded during the peak boll formation stage to till harvest of the crop i.e. 43$^{rd}$ SMW to till end of the crop which confirms that the late sown crop will be the worst hit by PBW.

### 3.2. Correlation studies

During three years of the study 2018–20, the population of PBW has showed increasing trends. Average population in pheromone traps was 4.48, 5.31 and 5.34 trap$^{-1}$ during 2018, 2019 and 2020 respectively. Standard weeks 36–38 (3$^{rd}$ September–23$^{rd}$ September) 51–3 (17$^{th}$ December–21$^{st}$ January) were minimum or no activity periods due to low temperature, while standard weeks, 40–44 (1$^{st}$ October–4$^{th}$ November) were high activity periods during these study years (Figure 1).

The population trends were correlated with minimum, maximum, and average temperature ($^0$C), morning and evening RH (%) and rainfall (mm). Minimum and maximum temperature has negative and non-significant correlation with population in pheromone traps, while average temperature had positive and significant correlation. Rainfall had negative and non-significant correlation during 2018 and 2020, while positive and non-significant correlation during 2019 as shown in Table 3. These results are in conformity with the work of Sarma et al., 2020, who reported that the PBW trap catches had a significant but

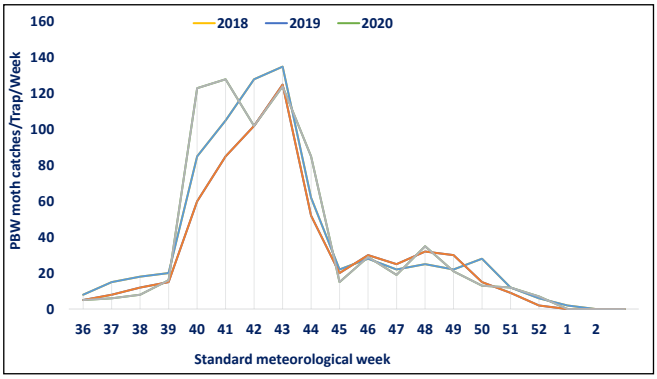


Figure 1: Pink bollworm moth catches/trap/week in the experimental fields

negative correlation with temperature (minimum) and relative humidity (evening) with correlation coefficient values r =-0.736 and r =-0.674 respectively. Abbas et al. (2022) reported standard weeks 11–15 and 31–35 were highly active, while SMW 20–26 were inactive periods of PBW. Temperature (20–30°C) had significant impacts to spread activities of PBW. Minimum (r=-0.165, -0.144, -0.582) and maximum (r=-0.078, -0.045, -0.192) temperature had negative and non-significant correlation with population in pheromone traps while average temperature has positive and significant correlation during study years (2018–2020). Population trends of PBW had shown increasing trends from 2018 to the subsequent years.

### 3.3. Economics

In present findings total yield in the protected condition i.e. technology demonstration plot was recorded higher i.e. 1965, 2055 and 2095 kg ha$^{-1}$ and lower yields of 1607, 1708 and 1725 kg ha$^{-1}$ in the control plot i.e. farmers practice during 2018, 2019 and 2020 respectively. The avoidable yield loss per cent ranged from 20.32–22.30 during the experimental period (Table 4). Accordingly highest net returns and BC ratio was recorded from the technology demonstrated plot compared to control. The present results are in accordance with the Manisha et al. (2023), who reported that the total yield in the protected condition was significantly higher (2593 kg ha$^{-1}$), whereas lower under unprotected conditions (1750 kg ha$^{-1}$) and avoidable yield loss of 32.52% and 30.91% was recorded during 2018 and 2019 respectively. Similarly, Banerjee (2002) observed

Table 3: Correlation between PBW trap catches and weather parameters

| Year | Temperature °C | | | Morning RH (%) | Evening RH (%) | Rainfall (mm) |
|---|---|---|---|---|---|---|
| | Max temp (°C) | Min temp (°C) | Average | | | |
| 2018 | -0.062±0.342 | -0.152±1.120 | 0.102±0.628 | 0.112±0.315 | -0.408±0.212 | -0.373±0.875 |
| 2019 | -0.025±0.253 | -0.144±0.630 | 0.290±1.210 | 0.348±0.351 | -0.355±0.142 | 0.141±0.743 |
| 2020 | -0.162±0.590 | -0.582±1.150 | 0.321±0.713 | 0.436±0.343 | -0.338±0.172 | -0.575±1.648 |

Table 4: Adoption of cotton growers about the management practices for control of pink bollworm

| Sl. No. | Statement | Adoption | | |
|---|---|---|---|---|
| | | FA | PA | NA |
| 1. | Do you terminate cotton crop by December end destroy the plant stubbles | 14(17.5) | 42(52.5) | 24(30.0) |
| 2. | Do you follow deep ploughing in month of March and April followed by cleaning operation | 16(20.0) | 48(60.0) | 16(20.0) |
| 3. | Do you adopt sowing in the month of June - July | 22(27.5) | 58(72.5) | 0(0.0) |
| 4. | Do you adopt early Bt cotton variety sowing | 08(10.0) | 13(16.25) | 59(73.75) |
| 5. | Do you adopt sowing of non-Bt refugia around Bt cotton | 15(18.75) | 52(65.0) | 13(16.25) |
| 6. | Do you adopt crop rotation for control of pink bollworm | 22(27.5) | 58(72.5) | 0(0.0) |
| 7. | Do you install four pheromone traps per acre for moni-toring the moth activity of PBW | 43(53.75) | 13(16.25) | 24(30.00) |
| 8. | Do you adopt recommended dose of Nitrogenous ferti-lizers | 17(21.25) | 28(35.00) | 35(43.75) |
| 9. | Do you monitor for pink bollworm incidence regularly | 13(16.25) | 43(53.75) | 24(30.00) |
| 10. | Do you destroy fallen squares, rosette flowers and dam-aged bolls every week | 36(45) | 44(55.0) | 0(0.0) |
| 11. | Do you use Azadirachtin formulation for spraying at the time of flowering | 18(22.5) | 19(23.75) | 43(53.75) |
| 12. | Do you avoid mixing and excess dose of insecticides | 19(23.75) | 43(53.75) | 39(48.75) |
| 13. | Do you avoid the use of synthetic pyrethroids at the starting stage of the crop | 14(17.5) | 27(33.75) | 24(30.00) |
| 14. | Do you store cotton plant debris for fire purpose | 12(15.00) | 51(63.75) | 17(21.25) |
| 15. | Do you allow grazing the crop by cattle after last picking to destroy pest affected plant debris | 14(17.5) | 28(35.00) | 38(47.50) |

21.43% avoidable yield loss due to bollworm complex in cotton crop. In accordance to the present findings, Chavan et al. (2009) stated that mean yield of cotton obtained from protected plots was 10.45 q $ha^{-1}$ and from unprotected plots 7.51 q $ha^{-1}$. Likewise, Jadhav et al. (2019) observed 21.09 q $ha^{-1}$ seed cotton yield in protected conditions, whereas 2.65 q $ha^{-1}$ was recorded in the control.

*3.4. Adoption of IPM strategies*

The contents of the Table 5 on the adoption of management practices for control of PBW, 52.5 % respondents partially adopted to terminate the cotton crop by December end and destroyed the plant stubbles followed by 17.5% fully adopted, 60.00% partially adopt deep ploughing in the month of March and April followed by cleaning operation, while 20.00% fully adopted. 72.5% partially and 27.5% expressed their full willingness to sow the crop at normal timing i.e. in the month of June–July. The sowing of non-Bt refugia partially sown by 65.00% respondents and 18.75 % fully adopted sowing of non Bt refugia. 35 % and 21.25% respondents partially and fully accepted to adopt proper dose of nitrogen fertilizer. Regarding pheromone trap installation, 53.75% partially installed and 16.25% fully installed and 30.00% not installed. 17.5% of the people expressed their willingness to avoid the usage of synthetic pyrethroids at the initial stage of the crop. 35% people

Table 5: Economics and net returns of the experiment

| Particulars | 2018 | | 2019 | | 2020 | |
|---|---|---|---|---|---|---|
| | Treatment | Control | Treatment | Control | Treatment | Control |
| Average yield (kg $ha^{-1}$) | 1965 | 1607 | 2055 | 1708 | 2095 | 1725 |
| Gross income (₹ $ha^{-1}$) | 97,268 | 79,547 | 95,352 | 77,031 | 87,990 | 69,724 |
| Total cost of cultivation (₹ $ha^{-1}$) | 44950 | 48,960 | 45,050 | 47,960 | 42,835 | 43,150 |
| Net returns (₹ $ha^{-1}$) | 52,318 | 30,357 | 50,302 | 29,071 | 45,155 | 26,574 |
| Benefit: cost ratio | 1.95:1 | 1.40:1 | 1.81:1 | 1.50:1 | 1.85:1 | 1.51:1 |
| Price $kg^{-1}$ at har-vest (December) | 49.50 | 49.50 | 46.4 | 45.1 | 42.00 | 39.26 |

1 US $: 74.0 during 2018; 1 US $: 70.85 during 2019; 1 US $: 70.96 during 2020

partially expressed their willingness to graze the crop by cattle after last picking and destroy the pest affected plant debris while 47.5% expressed their non acceptance to adopt the same practice. Khodake et al., 2019 stated that 67.5% had medium level of knowledge about management practices for control of PBW, whereas 13.75% and 18.25% of the respondent farmers were having low and high level of knowledge about the management practices for control of PBW. Khodake et al., 2020 observed that 77.50% of the respondents had medium level of adoption of management practices for control of pink bollworm. The percentage of respondents having low level of adoption was 08.75%, whereas 13.75% respondents were having high level of adoption.

## 4. CONCLUSION

Pheromone traps as forecasting tool are very useful to monitor the pink bollworm throughout the year under the optimum temperatures for the pink bollworm. Different weather parameters showed negative correlation with bollworm infestation. These models warn us against pest attack in the future from the pest losses. By adopting the integrated pest management strategies against this pest, farmers can avoid the yield losses up to 22.3%. 65% of the respondents had medium level of adoption of management practices for the control of PBW.

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