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Screening the Varietal Resistance and Mating Disruption Management of Cotton Bollworm *Helicoverpa armigera* and *Pectinophora gossipyilla* at Sibi Balochistan

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ABSTRACT

Cotton bollworms cause huge losses and are mainly controlled through the synthetic chemicals, however, chemical control does not always effective due to the larvae's obscure feeding habit. Therefore, varietal resistance and insect mating disruption by using of sex pheromone and light traps were used in present research. The results revealed overall highest seasonal population of *Helicoverpa armigera* (3.75±0.37) on cotton SS-32 variety, followed by (2.41±0.17), (2.35±0.21), and (2.00±0.19), IUB-13, Nayab-878, and J-5 *Pectinophora gossypiella* (3.00 ± 0.72) on cotton variety Nayab-878 followed by population of 2.99±0.27, 2.50±0.31, and 1.65±0.22 on cotton varieties J-5, SS-32 and IUB-13 respectively. In addition, maximum yield production was recorded from J-5 (1025 kg ha-1), followed by Nayab-878 (962 kg ha-1) and IUB-13 (835 kg ha-1), respectively. Results, of field trials revealed overall *H. armigera* (61.25±5.28/15 sex pheromone traps ha^{-1}) followed by (37.45±6.28/10 ha^{-1}) and (20.79 ± 4.28 /6 ha^{-1}) and *P. gossypiylla* (58.08±7.58 ha^{-1}) followed by (45.41±4.88/10 ha^{-1}) and (31.45±3.28/6 ha^{-1}) were captured, respectively. Further, lowest infestation level of *H. armigera* (2.25±0.28%/15 sex pheromone traps ha^{-1}) followed by (6.60±0.80 %/10 ha^{-1}), (6.60±0.80% /10 ha^{-1}) and (20.45±4.80% control plots) and *P. gossypiylla* (2.10±0.21 %/15 ha^{-1}) followed by (7.41±0.96 %/10 ha^{-1}), (9.45±0.98 % /10 ha^{-1}) and (19.15 ± 4.87 % control plots) were recorded, respectively. On the other hand, maximum number of *H. armigera* (24.30±4.35 /8 light traps ha^{-1}) followed by (22.00±3.30/6 ha^{-1}) and (17.50±3.12 /4 ha^{-1}) were recorded and *P. gossypiylla* (24.00±4.28 /6 ha^{-1}) followed by (21.00±3.40 /8 ha^{-1}) and (20.15±2.70 /4 ha^{-1}) were caught, respectively. As results, the lowest infestation level by *H. armigera* (7.60±1.12 % /6 light traps ha^{-1}) followed by (8.25±1.20 % /8 ha^{-1}), and (10.79±1.80 % /4 ha^{-1}) and (20.45±4.80 % control plots) and *P. gossypiylla* (6.10±0.90 % /8 ha^{-1}) followed by (7.45±1.15 % /6 ha^{-1}), (8.40±1.38 % /4 ha^{-1}) and (19.15±4.87% control plots) were recorded, respectively. Taken to gather, 10 or 15 sex pheromone traps/hectare and 6 and 10 light traps/ hectare should be installed in cotton crop to reduce the population frequency of bollworm and crop damage tendency in the cotton field for the better production.

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INTRODUCTION

Cotton (*Gossypium sp.*) also known as white gold is one of the important commercial crops of Pakistan. There are several factors are responsible for this low yield, but the most destructive factors is insect pests attack (Muhammad and Anjum, 2010). However, past studies revealed that the cotton crop is attacked by 1326 insect pests which is divided into two categories: sucking and bollworms pests. Among bollworms complex *Helicoverpa armigera* (Lepidoptera: Noctuidae), *Pectinophora gossypiella* (Lepidoptera: Gelechiidae), *Earias insulana and E. vitella* (Lepidoptera: Noctuidae) (Razaq *et al.*, 2004) are the considered the most important destructive pests damage bolls. And yield losses have been estimated up to 40% every year in Pakistan (Amin, 2016).To evade these losses, farmers mostly depend on the use of pesticides (Arif *et al.*, 2007).This has resulted in the increased use the applications of pesticides. Among those, the most and widely used control measure for cotton bollworms is the application of chemicals. However, chemical control does not always proved effective due to the larvae's internal and obscure feeding habit (Khidr *et al.*, 1990). These includes development of resistance to pesticides by major insect pests, environmental pollution, farmer illness, problems of health hazards and residues in food chain (Huang *et al.*, 2003; Graham and Barfoot, 2009; Khan *et al.*, 2010; Frank, 2012). However, the management of cotton bollworms is very difficult with insecticides alone since it is an internal feeder. So, potential solution is adoption of integrated pest management strategies plays a key role. Cotton pest management includes different strategies to be combined to manage the complex of pest bollworms in the recent past Henneberry (Henneberry and Naranjo, 1998).

In this context, integrated pest management is an essential and sustainable option for cotton production system which includes series of control measures and keeping the population of bollworms below economic threshold level. However, several control methods have been used for the management of this noxious group, but the entity-based majority of control methods does not meeting the requirement. Hence, to overcome the cotton bollworm infestation potential and eco-friendly Integrated Pest Management (IPM) is needed for the better cotton production system, particularly in Sibi Balochistan region. Addressing to this issue, management of cotton bollworms should be based on the IPM module. Therefore, the present research was subjected to develop the potential IPM for the management of cotton bollworm in Sibi Balochistan.

MATERIAL AND METHODS

The present research has been designed to develop the IPM based management for cotton bollworms particularly in Sibi, Balochistan. Therefore, a series of field experiments were conducted at the site area of main campus Mir Chakar Khan Rind University, Sibi Balochistan during 2021.

Screening the resistant cotton varieties against bollworm complex

In order to evaluate the most resistance cotton varieties, four cotton varieties such as Nayab-878, J-5, SS-32 and IUB-13 were tested against *H. armigera and P. gossypiella*. All the varieties were planted according to requirement and all agronomic practices were done accordingly.

Data observation and collection cotton boll infestation

Data of bollworms infestation were recorded from the cotton bolls from each cotton cultivar and damaged or infested bolls by two noxious species of bollworms *H. armigera* and *P. gossypiella.* Total 100 bolls randomly from each variety were plucked from the plants, brought in the laboratory for critically infestation examination. Cotton bolls were collected and examined on 90, 120, and 140 days after sowing. Entry hole by the bollworms as well as wart by pink bollworm in the inner side of the rind and standard symptoms of *H. armigera* was noted and recorded from the damaged boll. The percent damage in the bolls was calculated by following formula;

$$\text{Percent boll damage} = \frac{\text{No. of bolls damaged}}{\text{Total number of bolls}} \times 100$$

Evaluation of sex pheromones

To evaluate the efficiency of sex pheromone, traps have been used to capture adult moths of both species in the cotton field, during cotton season 2021. For this purpose, Nayab-878 cotton variety was planted.

Installation of Funnel Sex Pheromone Dispensers

Funnel type pheromone dispenser traps technique was used for adult mouth catches in cotton field. In this regard funnel type pheromone dispensers were purchased from Shani Enterprises, Agriculture Division, Multan-Pakistan. Three different densities of sex pheromone traps such as, 6, 10 and 15 traps per hectare were installed and traps were hanged 6 feet height position and 30 meter distance were maintained from each side. However, the specific lure capsule was attached to the funnel trap. The pheromone lures of sex traps were transformed at 15 days interval as practiced by Lykouressis *et al.* (2005), reported that lures of pheromones traps changed with intervals of 15-20 days.

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Installation of light traps

Light traps have been installed in the cotton field to attract the noctioude moth on cotton field condition. The light trap of mercury (ML-160 watt) BSE-G3 model placed on the light traps and all light traps installed 3 feet height from the ground level. Light trap mercury (ML-160 watt) BSE-G3 model turned on manually. Light trap with certain modifications were incorporated according to requirements of fields and trapped moths were evaluated. The trap (Jermy type) had four constituent parts i.e. collecting chamber, funnel shaped lid, light source and a lid from the top to protect from unexpected showers. The duration light is for 10-12 hours starting from 18.00 pm. Chloroform was used for the killing. The light traps were installed in four different places at weekly intervals. Killing jars were changed as required by hand and trapped insects were identified and counted. Further there is no any chemical application were imposed in the cotton field throughout the crop season.

Light trap installation layout

Unique concentrations was tested with light traps heights i.e., 3 feet with three replications of with each light trap size was installed. In addition, one control plots as untreated also performed in cotton field. Light traps devices installed with the support of iron stands at spaced at 25 m^2 intervals for each side and trap position. The plots was treated with light traps and never treated with any other control method. Funnel type light traps devices were used for capturing the population cotton noctuid moths. Each trap was suited with above mentioned concentrations and replaced at 4 week intervals. In total four light trap densities such as 6, 10, and 15 traps/hector with three replications were installed.

Crop Infestation Level %

The impact of pheromone dispensers and light trap treatments was determined by catched adult moths in the trap and crop damage assessed by examining the two major types of symptoms (Rossette shaped of flowers and cotton boll holes and bud damages). For percentage of damage appraisal was assessed at weekly basis by examining the 100 infested bolls total. Infested cotton bolls with symptoms were confirmed that damage was caused by bollworm complex. Damage of the crop was examined form the start of August mid-November. The damage and infestation levels of cotton boll and buds on each replication was analyzed and calculated by using the previously standard formulas of Oñate and Burton (1965) and Abbott (1925).

Data collection and analysis

Weekly population of captured moths were recorded from the traps and crop damage percentage was analyzed using one-way analysis of variance (ANOVA) followed by the post-hoc *Tukey's test*; to determine treatment differences. Efficiency was considered significantly differ at (***P < 0.05***). All the analyses were performed by using SPSS (SPSS Inc., Chicago, IL, USA) and GraphPad Prism, (Version 5.0).

RESULTS

Screening the resistant cotton variety against bollworm complex

The results indicate the overall population of two cotton bollworm species on different cotton varieties. Maximum population of *H. armigera* (3.75 ± 0.37) on cotton SS-32 variety, based on the evidence of green cotton boll damages symptoms and larval presences in the green boll was observed and recorded followed by (2.41 ± 0.17), (2.35 ± 0.21), and (2.00 ± 0.19), IUB-13, Nayab-878, and J-5, respectively. Furthermore, maximum larval population trend of *P. gossypiella* (3.00 ± 0.72) on cotton Nayab-878 variety, followed by (2.99 ± 0.27), (2.50 ± 0.31), and (1.65 ± 0.22), J-5, SS-32 and IUB-13 respectively (Figure 1). Consequently, remarkable differences in the population of both bollworm species were observed in various cotton varieties at statistical level (*P < 0.05,* post-hoc *tukey's test*).

Yield of differentiation among the cotton varieties at Sibi Balochistan during 2021

On the basis of results, remarkable change in yield was noted in cotton genotypes, which may be due to the difference in their ability to tolerate the infestation or population trend of cotton bollworm. Maximum yield production was recorded from J-5 (1025 kg ha-1), followed by Nayab-878 (962 kg ha-1) and IUB-13 (835 kg ha-1) as these cotton varieties demonstrated some immunity and tolerance to the both species of bollworm complexes (Table 1).

Overall captured moths in funnel type pheromone traps

As results indicates in Figure 2, overall moths population of *H. armigera* and *P. gossypiella* revealed overall captured moths by installed different numbers of traps such as 6, 10 and 15 traps/hectare. Consequently, significant difference was observed in various trap density per hectare (ANOVA:

DF=3, F= 3.15, P < 0.0239). However, the maximum average numbers of *H. armigera* moths (61.25 ± 5.28 /15 traps ha^{-1}) followed by (37.45 ± 6.28 /10 traps ha^{-1}) and (20.79 ± 4.28 /6 traps ha^{-1}) were observed and recorded, respectively. On the other hand, maximum moth population *P. gossipyilla* (58.08±7.58/15ha^{-1}) followed by (45.41±4.88/10 ha^{-1}) and (31.45±3.28 /6 ha^{-1}) were caught, which were significantly at ($P < 0.05$) compared than others pheromone trap density, respectively at ($P < 0.05$, *LSD turkey's test*).

Table No 1. Yield differentiation between the cotton varieties in the Sibi region, Balochistan during the 2021.

Cotton Variety Name	Yield (Kg ha-1)
Nayab-878	962
SS-32	535
J-5	1025
IUB-13	835

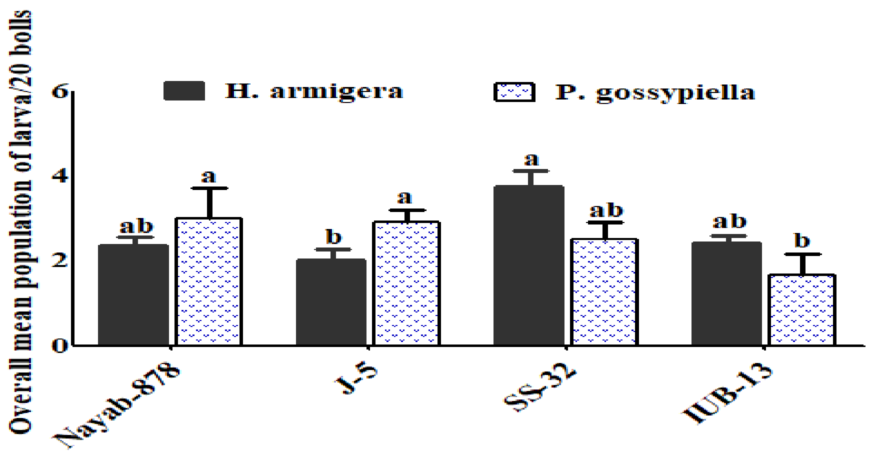

Figure 1. Overall based on boll damaged symptoms and presence of larva in cotton bolls of two species *Helicoverpa armigera* and *Pectinophora gossipyilla* on different cotton varieties. Values with the same letters were not significantly different at ($P < 0.05$, *LSD* test after one-way ANOVA).

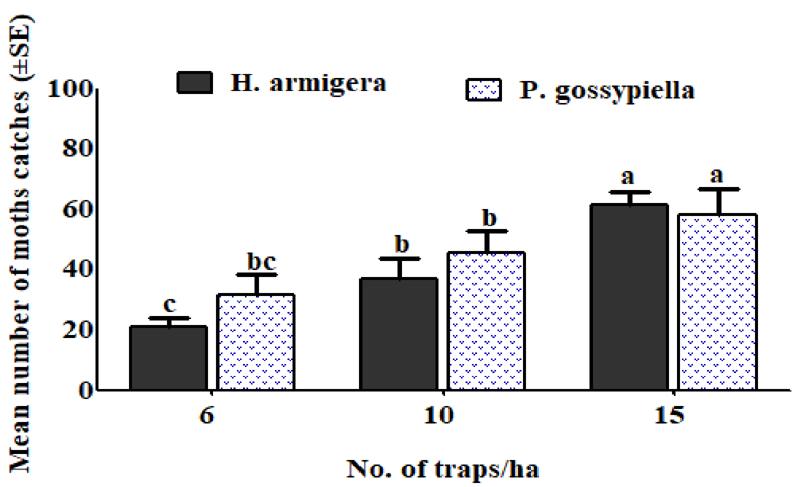

Figure 2. Captured noctioud adult moths in different pheromone trap density treatments (traps/ha). The values are shown as mean ± SE (3 replications). Further, Values with the same letters mean no significant difference at ($P < 0.05$, *Tukey's test* after two-way ANOVA).

Crop damage assessment percentage after using pheromone traps

Results illustrated in Figure 3 that remarkable difference in the infestation levels were observed in the various pheromone trap densities including control plot (df=3, F= 31.75, P < 0.0001). As results, the lowest infestation by *H. armigera* (2.25±0.28 % /15ha^{-1}) followed by (6.60±0.80 % /10 ha^{-1}), (6.60±0.80 % /10 ha^{-1}) and (20.45±4.80 % control plots) were recorded, respectively. Further, lowermost cotton crop damage infestation level based on the symptoms of *P. gossipyilla* (2.10±0.21 % /15 ha^{-1}) followed by (7.41±0.96 % /10 ha^{-1}), (9.45±0.98 % /10 ha^{-1}) and (19.15±4.87 % control plots) were recorded, respectively during the cotton cropping. During the research trial, the most damage symptoms of both bollworm species were recorded in the plots treated as control; in contrast, minimum damage symptoms were recorded in the plots in which 15 traps/ha were installed.

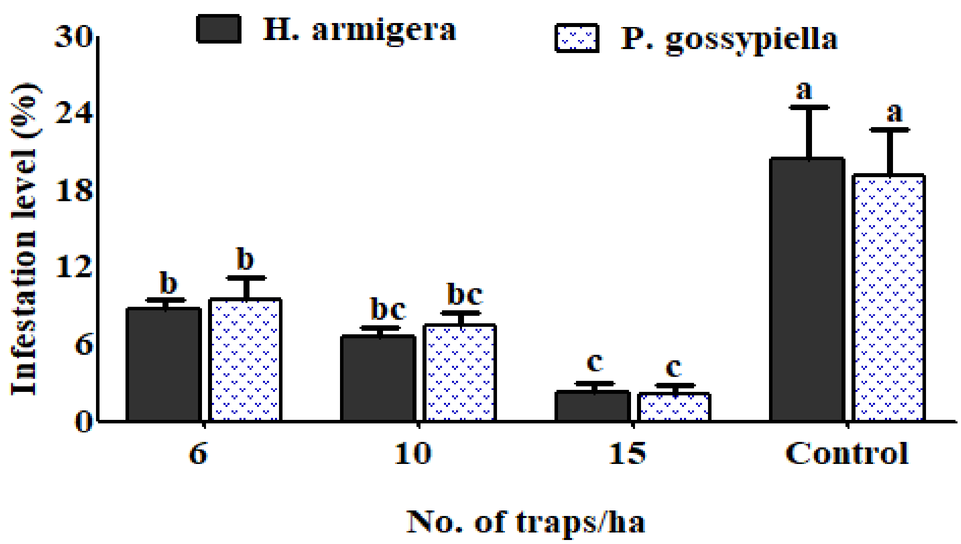

Figure 3. Crop damage assessment caused by *H. armigera* and *P. gossypiella* after utilization of the different funnel type pheromone traps densities in cotton field. Different letters indicates the significant difference between the trap treatments at (P > 0.05, *Tukey's test* after one-way ANOVA).

Mean captured moths by light traps

As results given in Figure 4 shows overall moths captured population of *H. armigera* and *P.gossipyilla.* As results revealed overall captured moths by installed different numbers of traps such as 4, 6 and 10 light traps/hectare, remarkably difference was observed in various trap density per hector (df=3, F= 355.8, P < 0.001). However, the maximum average number of moth species of *H. armigera* (24.30 ± 4.35 /8 light traps ha^{-1}) followed by (22.00 ± 3.30 /6 light traps ha^{-1}) and (17.50 ± 3.12 /4 traps ha^{-1}) were observed and recorded, respectively. On the other hand, maximum average number of moth species of Pink boll worm *Pectinophora gossipyilla* moths (24.00 ± 4.28 /6 light traps ha^{-1}) followed by (21.00 ± 3.40 /8 light traps ha^{-1}) and (20.15 ± 2.70 /4 light traps ha^{-1}) were caught, which were significantly at (*P < 0.05*) compared than others light trap density, respectively.

Crop damage assessment percentage after installation of light traps

Findings revealed in (Figure 5), showed that the remarkable difference in the infestation levels were observed in the various trap densities including control plot (df=4, F= 638.568, P < 0.0001). As results, the lowest infestation level and damage symptoms of *H armigera* (7.60 ± 1.12 % /6 light traps ha^{-1}) followed by (8.25 ± 1.20 % /8 light traps ha^{-1}), and (10.79 ± 1.80 % /4 light traps ha^{-1}) and (20.45 ± 4.80 % control plots) were recorded, respectively. An addition, further, lowermost cotton crop damage infestation level based on the symptoms of *P. gossipyilla* (6.10 ± 0.90 % /8 light traps ha^{-1}) followed by (7.45 ± 1.15 % /6 light traps ha^{-1}), (8.40 ± 1.38 % /4 light traps ha^{-1}) and (19.15 ± 4.87 % control plots) were recorded, respectively.

DISCUSSION

Host plant resistance is the most significant tool in any IPM program. It primarily affects the insect pest behavior due to which pests accept or reject the plant as suitable host. Due to these provisions plants show resistance, immunity, tolerance or susceptibility against insect pests (Javaid *et al.*, 2012). Screening trial is used to determine the resistance cotton cultivar against bollworm complex. In the present findings suggest that, none of these varieties showed complete resistant against *H. armigera* and *P. gossypiella.* Cotton cultivar SS-32 was found significantly susceptibility against both bollworm species as followed by IUB-13, Nayab-878, and J-5; consequently, high yield production was obtained from NAIB-878 compared to others varieties and demonstrated the immunity and tolerance to the both species of bollworm complexes. The results revealed that tested genotypes varied significantly in their susceptibility against bollworm complex. These findings are in conformity with Khan (2011), Salman *et al.* (2011), Ghafoor *et al.* (2011), Javaid *et al.* (2012), Asif *et al.* (2018).

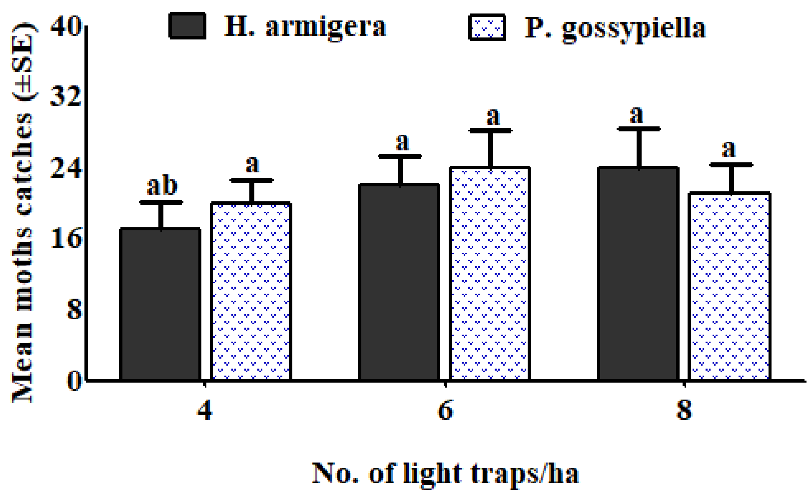

Figure 4. Captured response two noctioud adult moths *H. armigera* and *P. gossypiella*) in different light traps densities/ha. The values are shown as mean ± SE (3 replications). Further, Values with the same letters mean no significant difference at (P < 0.05, *Tukey's test* after two-way ANOVA).

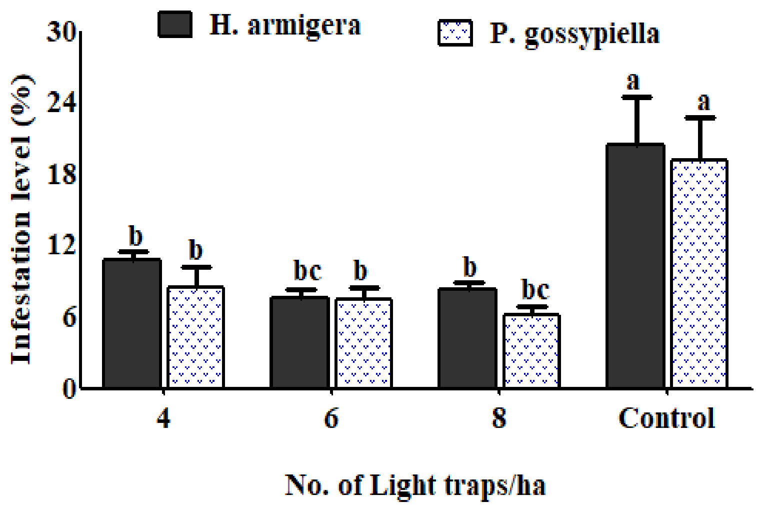

Figure 5. Crop damage assessment caused by *H. armigera* and *P. gossipyilla* after utilization of the different light trap densities in cotton field. Different letters indicates the significant difference between the trap treatments at (P > 0.05, *Tukey's test* after one-way ANOVA).

The mating disruption technique does not only provide the protection of the crops by controlling cotton bollworms, but is possible alternative of the synthetic chemicals and environmentally friendly (Chen and Klein, 2012). The applications of sex pheromones for mating disruption of cotton bollworms is expensive for farming community, since this technology is still not fully commercialized and accurate dose is not optimized yet. The optimal trap density of sex pheromone could exhibit the efficient mating disruption results in moth species. In present study, different trap densities were used to determine the most possible for mating disruption and in the response of both species of cotton boll worms revealed varied orientation response among tested trap densities. Recently studies (Witzgall *et al.*, 2008); was used different pheromone dispensers with different densities and dosage; to monitor and control the *Phyllocnistis citrella* and (Alfaro *et al.*, 2009; Khuhro *et al.*, 2020). The present research was also inspired against the same group of pests. Two trap density such as 15 and 10 trap/ hector were proved the most possible for maximum attraction of adult moths for both noctuid species, thus; bollworm population had been favored by Monsoon season as revealed by (Pratheepa *et al.*, 2010; Hussain *et al.*, 2014; Pan *et al.*, 2014; Reddy *et al.*, 2015). Different trap densities 6, 10 and 15 trap/ha, thus fewer studies have been installed different densities of pheromone traps, for example 31, 25 and 16 (Alfaro *et al.*, 2009) and 400 and 500 dispensers per ha. However, in the present study, the doses are possible very less than that used by Alfaro *et al.* (2009), 6.4 g/ha), and (Chen and Klein, 2012) 7.5 and 6.0 g/ha during the different cropping seasons. Using the lowest doses, we gained the significant results compared to control plots. Targeting to mating disruption management of cotton bollworm by using sex pheromone traps; assessment of crop damage can direct provide the clues relating to the potential of pheromone treatments. The frequency of damage symptoms indicates that applications of pheromones could reduce the significant more efficiently than control methods untreated. Subsequently, 15 and 10 traps/ha^{-1} were proved clearly in terms, caught much more moths and remarkable decrease the tendency of damage symptoms as compared other treatments 6 traps/ha^{-1} and then control plots. Compared with control plots, mating disruption technology provides clear advantages to farming community with crop protection and ecofriendly. Similarly, the results of light trap experiment was revealed that the maximum average number of moth species of *H. armigera and P. gossipyilla* were captured 6 light traps ha^{-1}, followed by 8 light traps ha^{-1} and 4 light traps ha^{-1}, which were significantly at (***P < 0.05***) compared than others pheromone trap density, respectively at (*P < 0.05, LSD tukey's test*). The incidence of damage symptoms indicates that applications of light trap could reduce the significant and more efficiently than control methods untreated. Subsequently, 6 and 8 light traps/ha^{-1} were proved clearly in terms, caught much more moths and remarkable decrease the tendency of damage symptoms as compared other treatments 6 traps/ha^{-1} and then control plots. Compared with control plots, mating disruption technology provides clear advantages to farming community with crop protection and ecofriendly.

CONCLUSION

On the basis of findings, it is suggested that cotton varieties such as J-5, and Nayab-878 were proved better and resistant in the terms of lowest bollworm infestation along with high yield performance. Thus both cotton varieties could be cultivated in future at the Sibi Balochistan region. For mating disruption management of both noctoiud species, 10 or 15 sex pheromone traps along with 6 or 10 light traps/ hectare should be installed in cotton agro- ecosystem of Sibi Balochistan to reduce the population frequency and crop damage tendency in the cotton field for the better production.

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REFERENCES

Abbott, W. S. 1925. A method of computing the effectiveness of an insecticide. Journal of Economic Entomology, 18: 265-67.

Alfaro, C., V. Navarro-Llopis and J. Primo. 2009. Optimization of pheromone dispenser density for managing the rice striped stem borer, *Chilo* *suppressalis* (Walker), by mating disruption. Crop Protection, 28: 567-72.

Amin, T. 2016. Pink Bollworm causes huge cotton loss. In Business Recoreder (Ed.).

Arif, M. J., G. Abbas and S. Saeed. 2007. Cotton in danger, Dawn, March 24th, pp. 4.

Asif, M., R. Muhammad, W. Akbar, M. Sohail and M. Awais. 2018. Field evaluation of advanced cotton genotypes against insect pest complex in agro-climatic conditions of Tandojam, Sindh. Journal of Innovative Sciences, 4: 83-89.

Chen, R.-z. and M. G. Klein. 2012. Efficacy of insecticides against the Rice Stem-borer, *Chilo suppressalis* (Walker)(Lepidoptera: Crambidae), and use of sex pheromones to time accurately the yearly application. International Journal of Pest Management, 58: 354-60.

Frank, S. D. 2012. Reduced risk insecticides to control scale insects and protect natural enemies in the production and maintenance of urban landscape plants. Environmental entomology, 41: 377-86.

Ghafoor, A., M. Hassan, Z. H. Alvi and S. Kousar. 2011. Impact of different varieties of stub cotton on population dynamics of whitefly at Faisalabad, Pakistan. Pakistan Journal of Zoology, 43: 25-28.

Graham, B. and P. Barfoot. 2009. Global impact of biotech crops: Income and production effects, 1996-2007. Agbioforum, 12: 129-37.

Henneberry, T. J. and S. E. Naranjo. 1998. Integrated management approaches for pink bollworm in the southwestern United States. Integrated pest management reviews, 3: 31-52.

Huang, J., R. Hu, C. Pray, F. Qiao and S. Rozelle. 2003. Biotechnology as an alternative to chemical pesticides: A case study of BT cotton in China. Agricultural economics, 29: 55-67.

Hussain, M., M. Akram, Q. Abbas, S. Ahmad, T. Babar and H. Karar. 2014. Impact of environmental factors on the population dynamics of leafhopper *Amrasca biguttula* ishida (Homoptera: Jassidae) on various transgenic cotton genotypes in Multan. Academic Journal of Entomology, 7: 27-31.

Javaid, M., M. J. Arif, M. D. Gogi, M. R. Shahid, M. S. Iqbal, R. Bibi and M. A. Shehzad. 2012. Relative resistance in different cultivars of Pakistani cotton against cotton whitefly. Academic Journal of Entomology, 5: 143-46.

Khan, M. J., M. S. Zia and M. Qasim. 2010. Use of pesticides and their role in environmental pollution. World Academy of Science, Engineering and Technology, 72: 122-28.

Khan, S. M. 2011. Varietal performance and chemical control used as tactics against sucking insect pests of cotton. Sarhad Journal of Agriculture, 27: 255-61.

Khidr, A., S. Kostandy, M. Abbas, M. El-Kordy and O. El-Gougary. 1990. Host plants, other than cotton, for the pink boll worm Pectinophora gossypiella and the spiny bollworm Earias insulana. Agricultural Research Review, 68: 135-39.

Khuhro, S. N., K. Abdullah, M. F. Hassan, M. A. Talpur and A. Keerio. 2020. Exploration of predatory spiders on cotton pests in sprayed and un-sprayed Cotton fields of ccri-Sakrand-Sindh-Pakistan. Journal of Applied Research in Plant Sciences, 1: 36-41.

Lykouressis, D., D. Perdikis, D. Samartzis, A. Fantinou and S. Toutouzas. 2005. Management of the pink bollworm *Pectinophora gossypiella* (Saunders)(Lepidoptera: Gelechiidae) by mating disruption in cotton fields. Crop Protection, 24: 177-83.

Muhammad, A. and S. Anjum. 2010. Studying the sucking insect pests community in transgenic BT cotton. International Journal of Agriculture and Biology, 12: 764-68.

Oñate, D. and T. Burton. 1965. Estimation of stem borer damage in rice fields.

Pan, H., B. Liu, Y. Lu and N. Desneux. 2014. Identification of the key weather factors affecting overwintering success of *Apolygus lucorum* eggs in dead host tree branches. PLoS One, 9: e94190.

Pratheepa, M., K. Meena, K. Subramaniam, R. Venugopalan and H. Bheemanna. 2010. Seasonal population fluctuations of cotton bollworm, *Helicoverpa armigera* (Hubner) in relation to biotic and abiotic environmental factors at Raichur, Karnataka, India. Journal of Biological Control, 24: 47-50.

Razaq, M., M. Aslam, S. A. Shad and M. Naeem. 2004. Evaluation of some new promising cotton strains against bollworm complex. Evaluation, 15: 313-18.

Reddy, G. V., P. Shi, C. Hui, X. Cheng, F. Ouyang and F. Ge. 2015. The seesaw effect of winter temperature change on the recruitment of cotton bollworms *Helicoverpa armigera* through mismatched phenology. Ecology and Evolution, 5: 5652-61.

Salman, M., A. Masood, M. Arif, S. Saeed and M. Hamed. 2011. The resistance levels of different cotton varieties against sucking insect pests complex in Pakistan. Pakistan Journal of Agriculture, Agricultural Engineering and Veterinary Sciences, 27: 168-75.

Witzgall, P., L. Stelinski, L. Gut and D. Thomson. 2008. Codling moth management and chemical ecology. Annual Review of Entomology, 53: 503-22.