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Efficacy and Feasibility of Various IPM Tools against PoD Borer (*Helicoverpa armigera*) of Chickpea in Thal Regions of Punjab

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MA conducted research and wrote the manuscript. MA, SA and MK collected the data. MR designed the experiment and cross checked data. KH and MK reviewed the literature. AG and NH analysis of results. MA and SA provided the research material. SA

Key words
Gram, *Helicoverpa armigera*, IPM, Feasibility, Yield, Thal

ABSTRACT

Polyphagous pest, *Helicoverpa armigera* is a major detrimental factor of gram affecting both quality and quantity of the produce in Thal regions of Punjab. Therefore, experiment was conducted to check the efficacy and feasibility of five IPM tools viz. Pheromone traps, Light traps, *Trichogramma chilonis*, *Bacillus thuringiensis*, T-shaped bird perches and Handpicking. Results showed the cumulative effects of all IPM components having 4.81, 4.96, 6.22 % foliage, pod and grain damage, 0.71 larva/plant with 32.28 % yield increase over control treatment. But Marginal Cost Benefit Ratio was -0.46. Light traps proved more efficient and feasible having low environmental risks having minimum percent foliage, pod and gain damage of 2.09, 0.71 and 0.29, respectively with 0.13 larval population/plant, maximum yield of 875 kg/ha with 68.84 % yield increase over control under current investigations. Light traps had ideal MCBR of 13.3 with net income Rs. 32000 followed by *B. thuringiensis* and hand picking having net income Rs. 11150 and 10300, respectively. *T. chilonis* and T-bird perches were least effective having net income 3850 and 5075, MCBR 5.13 and 3.12, respectively. Light traps had maximum adult catches of 706/ cropping season, which reduces the larval population by suppressing the egg laying of adults. Maximum adult catches were recorded during the month of July with 9.36/night having positive and significant correlation with temperature.

INTRODUCTION

Chickpea (*Cicer arietinum*) known as chana is important legume crop of South Asia. There are two different kinds of chickpea, kabuli and desi, based on shape, size and color of seeds. The crop is mostly sown under rainfed conditions. It is rich source of protein 24 %, carbohydrates 59.6 %, and minerals 3.2 % (Bakra *et al*., 2004). Globally chickpea is grown over an area of 13.54 million hectares with production of 13.10 million tons. India, Australia, Pakistan, Turkey and Myanmar are major chickpea producing countries (FAOSTAT, 2015). It has ability to tolerate high temperature by fixing atmospheric nitrogen (Cumming and Jenkins, 2011). However, the high yielding is limited by insect pests (Yogeeswarudu and Krishna, 2014). It is attacked by 57 different insect species among these *Helicoverpa armigera* (H) is very much important. It is highly polyphagous insect having a vast range of alternate host plants attacking on most of the horticultural, agricultural and ornamental crops (Sarwar, 2006; Patanker *et al*., 2001). Initially it feeds on fresh leaves and tender branches. It may leads to 30-40 % pod damage. Under favorable environmental conditions it may cause 80-90 % damage (Rehman, 1990; Sachan and Katti, 1994; Kassi *et al*., 2018; Javed *et al*., 2018). In northern thal areas of Pakistan 90 % pod damage has reported on unprotected chickpea fields. An outbreak of *H. armigera* was recorded during 2001-02 (Anonymous, 1987, 2002). A single female may lay up to 3000 eggs singly. Under agro-ecological zones of thal there are two activity periods of *H. armigera* i.e. 1st flush during November-December on fresh leaves and tender branches while 2nd flush during March-April on flowering and pods. It eats fresh seed inside the pods and cause significant losses to the crop yield. Due the increasing concern of environmental awareness of pesticide hazards has evoked worldwide interest searching alternatives of pest control. Therefore, it is necessary to adopt such pest control techniques which reduce insecticide application significantly. Various Integrated Pest Management (IPM) tools were used such as pheromone traps, light traps, *Trichogramma chilonis*, Bt toxin, bird perches and hand picking. These are important tool to control pest population. Pheromone and light traps are powerful attractants which mainly use to control and

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monitor lepidopterous pests (Malik and Ali, 2002; Dillon and MacKinnon, 2002). In Pakistan as well as rest of the world extensive studies were carried out to check the bioefficacy of *T. chilonis* and *B. thuringiensis* (Khalique and Ahmad, 2001). Bird perches encourage predator birds such as black drongo, house sparrow, blue jays, cattle egret etc (Gokhale and Ameta, 1991) to sit and eat live larvae. Therefore, current study was conducted to check the efficacy and feasibility of various IPM tools based on their Marginal cost benefit ratio under agro-ecological zones of Thal.

MATERIALS AND METHODS

Experiment was conducted at Arid Zone Research Institute, Bhakkar to evaluate the efficacy and feasibility of various IPM tools i.e. pheromone traps, light traps, *Trichogramma chilonis*, *B. thuringiensis*, T-shaped bird perches and handpicking in gram crop under rain fed conditions during 2017-18. Each treatment consists of 1 hectare area, same variety (including both Desi and kabuli) and sowing date with control treatment.

Pheromone traps

Pheromone traps @ 15/ha with lures (Z -11-hexadecenal) were used 30 days after sowing till harvesting. Each trap was hanged with wooden stick 1 m above the ground with 35±3 m apart. A cotton swab soaked with 2 ml of insecticide Spinosad 240 SC was placed inside the trap for the purpose of killing. Adult catches were recorded on daily basis. Pheromone lures were replaced after every 15 days intervals.

Light traps

Local made light traps @ 2/ha were installed 30 days before sowing till 30 days after harvesting. Trap was hanged 1.5 m above the ground. The light source was provided by alternate current with LED 24 watts from dawn to dusk. At the base of trap a poison bottle having potassium cyanide with a layer of plaster of parris was hanged for the killing purpose. Adult catches were recorded on daily basis.

Trichogramma chilonis

T. chilonis cards @ 75/ha were installed in two phase's i.e. vegetative and flowering stage. Cards were obtained biological control laboratory, Entomological Research Institute, AARI, Faisalabad. Cards having 500-600 eggs/card were tagged with plants at the canopy.

Bacillus thuringiensis

Two applications of Bt toxin were made on vegetative and flowering stage @ 1 g/liter of water.

T-Bird perches

T-shaped bamboo sticks of 0.5 m long were installed @ 45/ha at vegetative stage till harvesting in order to encourage the local birds to sit and eat the larvae.

Control

Only farmer based treatments were applied with no additional application of other treatments.

Efficacy of all the components was assessed on the bases of total catches/cropping season, % foliage, pod and grain damage, average larval population/plant, grain yield (kg/ha), yield increase over control and Marginal cost benefit ratio by using following statistical equations.

$$\text{Pod damage (\%)} = \frac{\text{Number of damage pods}}{\text{Total number of pods}} \times 100$$

$$\text{Foliage damage (\%)} = \frac{\text{Number of damage branches}}{\text{Total number of branches}} \times 100$$

$$\text{Grain damage (\%)} = \frac{\text{Number of damage grains}}{\text{Total number of grains}} \times 100$$

$$\text{Yield increase (\%)} = \frac{\text{Yield gain} - \text{Yield of control}}{\text{Yield of control}} \times 100$$

$$\text{Marginal CBR} = \frac{\text{Net Income (Rs)}}{\text{Cost of treatment (Rs)}}$$

Statistical analysis

The experiment was analyzed by using statistical software i.e. Statistix 8.1, Minitab 13 and Microsoft Excel 2010.

RESULTS AND DISCUSSION

Different IPM components were evaluated based on different parameters at different growth stages of crop. Total adult catches during the whole cropping season were 136 and 706 in pheromone and light traps, respectively. Total 10365 other insects were also attracted including moths, beetles, flies and some beneficial insects etc. Total 1232 larvae were eradicated by handpicking during the cropping season. *Helicoverpa* usually appears on crop in two phases, 1st phase at vegetative stage during Nov-Dec while 2nd phase at flowering stage during Feb-Mar. At vegetative stage damage was estimated on foliage or young branches. Overall impact of all the IPM components showed 4.81 % damage to foliage, 4.96 % pod damage, 6.22 % grain damage, 0.71 larvae/plant, grain yield 704 kg/ha with 32.28 % yield increase over control. However, there was different efficacy of IPM components when studied separately. Light traps proved best with minimum damage to foliage, pods and grains. There was minimum larval population (0.13/plant), maximum grain yield of 875 kg/ha and maximum increase in yield 68.84 % over control followed by T1 (pheromone traps), T4 (*B. thuringiensis*), T6 (Handpicking), T5 (T-Bird perches) and T3 (release of *T. chilonis*). T7 (Farmer practice) results were not satisfactory as it had maximum foliage damage 10.58 %, pod damage 13.79 %, grain damage 15.18 % and larval population 1.12/plant. There was minimum grain yield of 536 kg/ha as shown in Table I. Release of *T. chilonis* and T-Bird perches depicted minimum yield increase over control 8.58 and 12.50 %, respectively. It was very much important for the IPM tools availability and feasibility for the farmers of thal. The tool which is easily available, least cost and maximum output should be adopted. Table II shows the availability and feasibility of all the IPM tools under agro-ecological zones of thal. Pheromone traps and lures were only available from big city markets and more expensive than other tools having cost Rs 17500/ha. *T. chilonis* are least cost Rs 750/ha but have a risk of highly effected by environmental factors. *B. thuringiensis* is expensive and not easily available in local markets. T-Bird perches can be easily prepared at home and least cost of Rs 1625/ha. Hand picking is effective but it requires more labor and time. Light traps proved best treatment as it easily available in local markets or can be manufacture at home and least cost. In order to confirm the suitability of these tools the net income and marginal cost benefit ratio was calculated as shown in Table III. Light traps gained maximum net income of Rs 32000/ha followed by *B. thuringiensis* and Handpicking with net income Rs 11150 and 10300/ha, respectively. Light traps have maximum cost benefit ratio. By spending Rs 1/ha it gives output 13.3 Rs/ha followed by cost benefit ratio of *T. chilonis* (1:5.13), T-Bird perches (1:3.12), *B. thuringiensis* (1:2.62), Handpicking (1:2.06) and Pheromone traps (1:0.42). While cumulative impact of all IPM tools exerted negative benefit cost ratio (1:-0.46). So, to apply all the components in a combined way will not be suitable under thal conditions having unexpected yield due to uneven rains and climate change. Keeping in mind best treatment the light traps further studies were carried out to verify its results on gram as a successful IPM tool in Thal. Light traps suppressed larval population of *H. armigera* by reducing the moth population in the crop field. Population of adult moth catches in light traps was positive and highly significant with larval population in the field. Moth catches in the light traps were indicator of pest attack on crop to start a suitable control strategy. Periods of peak catches were May-August in light traps with maximum larval population on the mungbean crop as shown in Figure 1. During that period pod borer feed on mungbean and after that it shifts on gram during month of December. Maximum 9.39 adult catches/night/light tap were recorded during the month of July with maximum larval population 0.97/plant on gram crop during the month of April. Table IV shows the correlation and regression studies of adults catches in the light traps. Adult catches and larval population had positive and highly significant correlation with temperature and humidity. Temperature showed 74.5 and 67.1 % impact on per unit population change in adult catches and larval population, respectively. Humidity had non-significant impact on change in adult and larval population. Researchers mostly evaluated IPM modules on the bases of pod damage, grain yield, % increase and cost benefit ration. There was a 4.96 % pod damage and 32.28 % increase in yield over control when studied on cumulative bases. Navi *et al*. (2018) used pheromone lures, bird perches, botanicals and chemical as IPM package. He concluded minimum pod damage 6.57 % in IPM block. Alam *et al*. (2011 and 2012) also confirmed our results who conducted different experiments to evaluate IPM packages against *Helicoverpa* on tomato crop. He concluded 74.5 % reduction in fruit infestation with low grade infestation level of 5.47 % in IPM treated blocks. T_4 (*B. thuringiensis*) showed 5.36 % pod damage. These results confirmed by Jerusa and Thakur (2018) they reported Bt + Handpicking approach proved better with pod damage 2.11 % as compared to other treatments. Handpicking was most cost effective approach. This difference may be because they used two components in a combined way. Bhede *et al*. (2014) reported pod damage 5.58-14.39 % with minimum pod borer population of 0.56/m row as compared to the non IPM block. Ugale *et al*. (2011) confirmed current results regarding yield increase who concluded 39.27 and 34.68 % increase in yield as compared to the conventional method block of two gram varieties. T_3 (*T. chilonis*) results were not satisfactory as it depicted maximum pod damage, larval population and minimum yield increase which confirmed by Wakil *et al*. (2009) who concluded that release of *T. chilonis* did not control pod borer. Based on the cost befit ratio, handpicking was most effective method for controlling pod borer. T_2 (light traps) proved best in term of low larval population by suppressing adult population and ideal cost benefit ratio. The success of light traps confirmed by Farman-Ullah *et al*. (2015) evaluated impact of light traps on field infestation and population of *Helicoverpa* in gram. Population levels of larvae ranged from 0.25-0.30/plant with pod damage 4.02-5.46 % under two treatments of light traps. Dillon and MacKinnon (2002) tested nine light traps in 16 hectare area. They reported light traps a successful tool to reduce egg laying of *Helicoverpa* by suppressing their egg laying. Total 29470 moths were captured in a year. Marginal CBR as reported by Gopali *et al*. (2009) of bird perches in IPM against *Helicoverpa* was higher (1:5.47) when compared with current experiment. Some scientists used seed crops such as barley and millet as perches due to this they may have high efficacy. Current studies were totally based upon rain fed conditions.

Table I. IPM chart showing effectiveness of various tools.

Treatments	Total catches/season	Average foliage damage (%)	Pod damage (%)	Grains damage (%)	Average larval population/ plant	Grain yield (kg/ha)	Yield increase over control (%)
T_1= Pheromone traps	136 (A)	5.27bc	3.56b	3.49b	0.82bc	785.0ab	46.46
T_2= Light traps	706 (A)	2.09a	0.71a	0.29a	0.13a	875.0a	68.84
T_3= *Trichogramma* cards	-	6.96c	7.92c	6.81b	0.92b	582.0c	8.58
T_4= *Bacillus thuringiensis*	-	4.56b	5.36bc	9.02c	0.72b	690.0b	28.73
T_5= T-Bird perches	-	6.28c	7.28c	12.42c	1.03c	603.0bc	12.50
T_6= Hand picking	1232 (L)	3.69ab	4.95b	5.34b	0.63b	689.0b	28.54
Cumulative impact of IPM		4.81	4.96	6.22	0.71	704	32.28
T_7= Farmer practice	0.00	10.58d	13.79d	15.18c	1.12c	536.0c	

A: adult; L: larvae.

Table II. Feasibility/availability of various IPM tools under agro-ecological zones of Thal.

Tools	Available from local markets	Available within 400 km distance	Available from foreign markets	Possibility to perform/ manufacture at home	Effects of environmental risks e.g. wind, rain etc.	Cost/ ha (PKR)
Pheromone traps	No	Yes	Yes	No	Medium	17500.0
Light traps	No	Yes	Yes	Yes	Low	2400.00
Trichogramma cards	No	Yes	No	No	High	750.00
Bacillus thuringiensis	No	No	Yes	No	Medium	4250.0
T-Bird perches	No	No	No	Yes	Medium	1625.00
Hand picking	-	-	-	Yes	Medium	5000.0

Table III. Effect of different IPM components on net income and marginal benefit cost ratio.

Treatments	Yield (kg/ha)	Additional yield over control (kg/ha)	Additional income over control (Rs/ha)	Treatment Cost (Rs/ha)	Net income (Rs/ha)	Marginal BCR ratio
T_1	785	249	24900	17500	7400	0.42
T_2	875	339	33900	2400	32000	13.3
T_3	582	46	4600	750	3850	5.13
T_4	690	154	15400	4250	11150	2.62
T_5	603	67	6700	1625	5075	3.12
T_6	689	153	15300	5000	10300	2.06
Cumulative BCR	704	168	16800	31525	-14725	-0.46
T_7	536					

Table IV. Correlation and regression studies of most effective IPM tool.

Parameters	Temperature °C	Humidity %	Regression equation	Impact (%)	
Adult catches	0.863 (0.00)	-0.689 (0.013)	$= - 30.1+0.622 X_1+ 0.386 X_2$	X_1	X_2
				74.5 **	4.6 ^{ns}
Larval population/plant	0.821 (0.001)	-0.625 (0.030)	$= - 3.81+0.0734 X_1+0.0541 X_2$	67.3 **	8.3 ^{ns}

X_1: Temperature; °C X_2: Humidity %.

That's why these types of perches cannot be used due to their high water requirement. Some other scientists also tested several IPM techniques to control *Helicoverpa armigera*. Rahman *et al*. (2016) studied different IPM approaches against *Helicoverpa* on tomato crop. He reported 6.98-54.90 % yield increase over control and 0.69-3.41 Marginal BCR in different IPM approaches. Mahmudunnabi *et al*. (2013) concluded pod infestation ranged from 5.19-16.32 % with cost benefit ratio 0.64-2.11 under different treatments. Suganthy and Kumar (2000) concluded that IPM was best treatment with 37 % larval population reduction, minimum pod damage (9.4 %) and ideal cost benefit ratio (1:6.3) as compared to other treatments. While bird perches exerted 23% suppression of larval population.

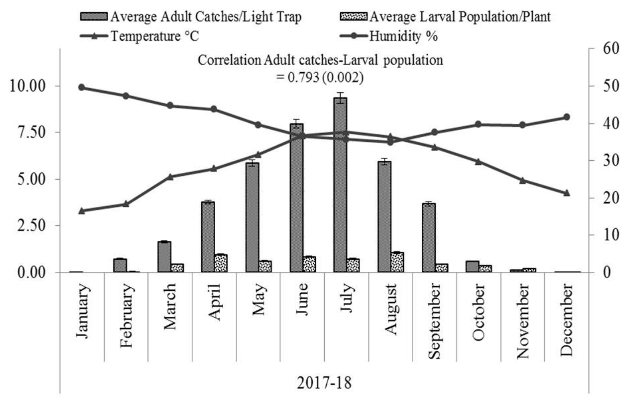

Fig. 1. Relationship of adult catches verses field population of pod borer in light traps.

CONCLUSION

Cumulative impact of all IPM components had significantly decrease pod damage, grain damage and larval population but it is not feasible to use all these components as they have negative Marginal cost benefit ratio. Under agro-ecological zone of thal, light traps were best tool for monitoring as well as suppression of pod borer population. Under these conditions the light traps can be improvised as solar based traps to improve its efficacy. As high cost and availability of electricity is big problem for the adaptation of electric based light traps.

Statement of conflict of interest

The authors declare there is no conflict of interest.

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