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**Bhumika Kapoor**
Division of Entomology, Faculty of Agriculture, Sher-e-Kashmir University of Agricultural Sciences & Technology of Jammu, Chatha, Jammu, Jammu Kashmir, India

**Uma Shankar**
Division of Entomology, Faculty of Agriculture, Sher-e-Kashmir University of Agricultural Sciences & Technology of Jammu, Chatha, Jammu, Jammu Kashmir, India

**Corresponding Author:**
**Bhumika Kapoor**
Division of Entomology, Faculty of Agriculture, Sher-e-Kashmir University of Agricultural Sciences & Technology of Jammu, Chatha, Jammu, Jammu Kashmir, India

# Trap catches of *Helicoverpa armigera* Hubner and *Maruca vitrata* fabricius and their natural enemies on black gram (*Vigna mungo* L. Hepper)

**Bhumika Kapoor and Uma Shankar**

## Abstract
The monitoring data on pheromone traps showed that the early detection of *Helicoverpa* and *Maruca* moth catch was noticed during 8$^{th}$ and 10$^{th}$ standard week with 0.33 and 1.22 moths catches, respectively during summer in Chatha farm, SKAUST-J. A progressive rise was noticed up to 19$^{th}$ standard week with the peak activity of 78.62 *Helicoverpa* moths per trap per week and 26.89 *Maruca* moths during same 21$^{th}$ standard week, respectively. The regression analysis indicated that all the weather parameters together were responsible for a significant variation of 69.0 and 73.60 per cent on the adult incidence of spotted pod borer and gram pod borer, respectively. Natural enemies such as Tachinid fly (*Nemorilla maculosa)*; Predatory Yellow Jacket Wasp; Rove beetle; Coccinellid beetles (*Coccinella septempunctata* and *C. sexmaculata*); Damsel fly*;* Spined soldier bug and different types of spiders were recorded as the dominant predatory insects against the Spotted pod borer and *Helicoverpa* in black gram ecosystem. Apart from predators, a larval endo-parasitoid, *Campoletis chlorideae* and naturally infected *H. armigera* larvae with the virus (*Ha*NPV) were recovered from the black gram experimental field.

**Keywords:** Pheromone traps, *Helicoverpa armigera, Maruca vitrata*, natural enemy, *Vigna mungo* L

## Introduction
Urd bean (*Vigna mungo* L. Hepper), is considered as the major source of dietary protein [20] and an important food legume crops of India cultivated in kharif, rabi and zaid /summer seasons in various agro-ecological zones. In Jammu and Kashmir state, the area, production and productivity of black gram in Jammu division is 6.381 thousand hectares, 2.144 thousand tonnes and 335.98 kg/ha, respectively [3]. In India, gram pod borer, *Helicoverpa armigera* Hubner and spotted pod borer, *Maruca vitrata* Fabricius are recorded as the serious pests of grain legumes (pigeon pea, cowpea, mung bean, field bean and black gram) causing pod as well as seed damage [35, 21, 33]. The annual yield loss incurred due to the ravages of insect pest complex has been estimated at about 30 per cent in urd bean and mung bean [14]. *Helicoverpa armigera* is a cosmopolitan and serious pest causing maximum damage to the crop during pod formation stage of all legumes in the world. The spotted pod borer is a major pantropical insect of grain legumes that feed on flowers, buds, and pods by webbing them. In the past years, farmers mostly depend on inorganic insecticides to regulate these insect pests directing to elevated risk of environmental contamination, biodiversity loss and repeated application of insecticide heightened the risk of resurgence and resistance [26]. So, there is need to incorporate innovative yet environmental friendly techniques such as introduction of sex pheromone traps and natural enemies, where the practical applications of these techniques in pest management have been reviewed recently [37]. Sex Pheromones are chemicals for species specific communication and produced by females to attract a mate and are most well-known for adult Lepidopterans. Pheromone traps have been exploited for three useful applications such as monitoring, mass trapping and mating disruption. They are therefore handy tools for tracking invasive species in the establishment phase [8, 16] or for population monitoring to determine the extent of an outbreak area and the effectiveness of eradication campaigns [5]. Influences of weather factors are often correlated to identify positive or negative impacts on trap captures, moth activities and pest population build-up [11, 28, 19, 23]. The pest abundance, in nature, is controlled by their natural enemies: parasitoids, predators and pathogens, a form of ecologically approach in pest management that uses one kind of organism (the “natural enemies”) to control another (the pest species) [13, 36]. In order to explore these aspects for

Effective management of the pest in the Jammu region, the studies on pest monitoring by pheromone traps and seasonal abundances of natural enemies on black gram crop were conducted.

## Materials and Methods

The experiment trail was laid out at Research Farm, Chatha, SKUAST-J using pheromone traps in black gram crop during summer, 2018. The Adult trap catches of Gram pod borer, *H. armigera* and Spotted/Legume pod borer, *M. vitrata* were recorded using Fero-T traps @ 10-12/ha with their septa, procured from Pest Control India (PCI) Pvt. Ltd. The septa were replaced at fortnightly interval. The traps were installed at 20 m distance in field at 1 m above crop canopy. The adult pheromone trap catches were recorded at weekly intervals during the morning hours and mean population were calculated accordingly. Similarly, the activities of natural enemies were also recorded at the three important stages i.e. vegetative, flowering and pod development stage in black gram agro-ecosystem. Then, the correlation and regression analysis of pheromone traps catches of adult moths of different borer pests with weather parameters viz., maximum and minimum temperature, morning and evening relative humidity, rainfall and wind speed were calculated using statistical procedures. Similarly, the seasonal abundance of natural enemies was correlated with the environmental variables. The meteorological data for the above analysis were obtained from the Meteorology section of SKUAST-Jammu.

## Results

The adult abundance of different pod borers was noted at weekly intervals from 7$^{th}$ Standard Week (SW) to 23$^{rd}$ SW on black gram during 2018, respectively and is presented in Table 1.

**Table 1:** Pheromone trap catches of adult moths of different borer pests on summer black gram during 2018

| SW | Month & Year | Trap catches of *Maruca* adults | Trap catches of *Helicoverpa* adults | Maximum temperature (°C) | Minimum temperature (°C) | R.H morning % | R. H evening % | Rainfall mm | Wind speed Km/hr |
|---|---|---|---|---|---|---|---|---|---|
| 7 | 12-Feb | 0 | 0 | 20.5 | 7.7 | 92 | 54 | 6.7 | 4.8 |
| 8 | 19-Feb | 0 | 0.33 | 24.2 | 9.8 | 87 | 54 | 0.5 | 2.9 |
| 9 | 26-Feb | 0 | 0.67 | 24.5 | 12.2 | 84 | 58 | 0.8 | 3.6 |
| 10 | 05-Mar | 1.22 | 1.33 | 27.2 | 10.3 | 88 | 43 | 0 | 3.2 |
| 11 | 12-Mar | 1.44 | 4.33 | 29.2 | 11.6 | 84 | 38 | 0 | 3.6 |
| 12 | 19-Mar | 2.44 | 6 | 28.2 | 12.3 | 84 | 45 | 1.1 | 4.3 |
| 13 | 26-Mar | 5.56 | 11.95 | 32.4 | 13.6 | 84 | 35 | 0 | 3.6 |
| 14 | 02-Apr | 7.33 | 16.67 | 33.1 | 17 | 77 | 39 | 0 | 3.2 |
| 15 | 09-Apr | 9.74 | 25.33 | 31.7 | 16.3 | 78 | 36 | 3.8 | 4.9 |
| 16 | 16-Apr | 13.89 | 35.64 | 30.4 | 16 | 77 | 45 | 2.6 | 5.9 |
| 17 | 23-Apr | 14 | 47.33 | 38.5 | 16.9 | 66 | 20 | 0 | 3.3 |
| 18 | 30-Apr | 19 | 59.71 | 36.5 | 20.2 | 60 | 30 | 1 | 5.8 |
| 19 | 07-May | 22.33 | 78.62 | 36.2 | 19.4 | 61 | 26 | 0.7 | 6.4 |
| 20 | 14-May | 24.89 | 52 | 37.2 | 21.1 | 57 | 26 | 0.4 | 6.3 |
| 21 | 21-May | 26.89 | 34.33 | 41.3 | 18.6 | 49 | 15 | 0 | 4.3 |
| 22 | 28-May | 3.67 | 25.67 | 42.8 | 23.5 | 47 | 15 | 0 | 5.4 |
| 23 | 04-Jun | 1.22 | 11.67 | 38.2 | 27.5 | 68 | 38 | 22.8 | 5.2 |

### Trap catches of the adult moths of spotted pod borer, *M. Vitrata* and gram pod borer, *H. armigera*

The data showed that the earliest detection of *Helicoverpa* during 8$^{th}$ standard week i.e. 0.33 moths catches when mean maximum temperature was 24.2 $^{0}$C, minimum temperature was 9.8 $^{0}$C, rainfall 0.5 mm, R.H. evening 54 % and R.H. morning 87% and wind speed 2.9 km/hr. However, in the case of *M. vitrata*, the earliest moth catch was obtained during 10$^{th}$ standard week i.e. 1.22 moths catches when corresponding mean maximum, mean minimum temperatures, rainfall, R.H. evening R.H. morning and wind speed were 27.2 $^{0}$C, 10.3 $^{0}$C, 0.0 mm, 88.0 %, 43.0 % and 3.2 km/hr, respectively. A gradual increase was noticed up to 19$^{th}$ standard week with the peak activity of 78.62 *Helicoverpa* moths per trap per week and 26.89 *Maruca* moths during same 21$^{th}$ standard week, respectively. The corresponding maximum temperature during 19$^{th}$ SW was recorded to be 36.2 °C and minimum temperature of 19.4 °C for *Helicoverpa* whereas during 21$^{st}$ standard week the maximum temperature of 41.3 °C and minimum temperature of 18.6 °C for *Maruca* (Table 1, Fig. 1-2).

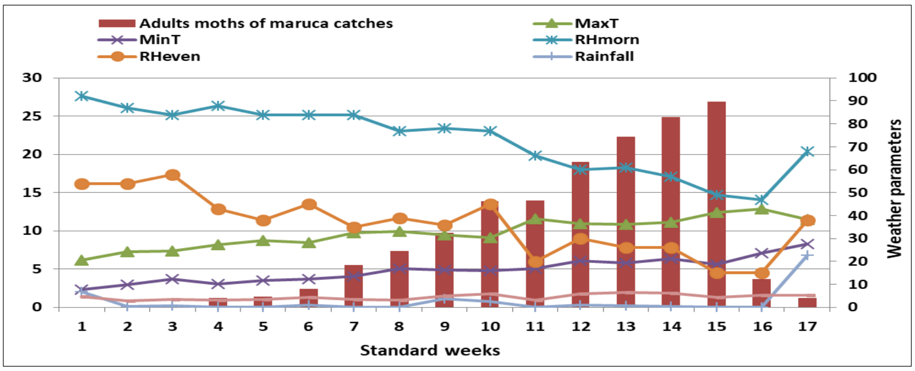


**Fig 1:** Pheromone trap catches of adult moths of *Maruca vitrata*

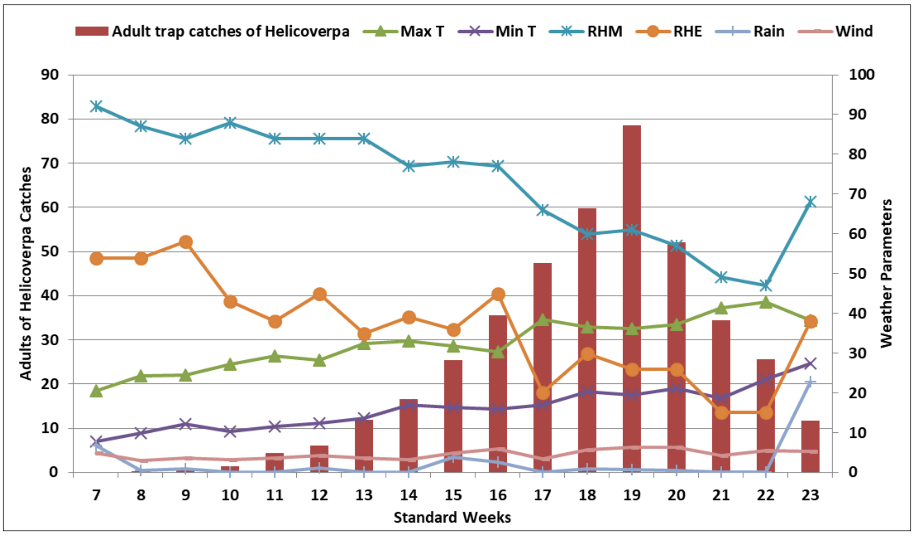


**Fig 2:** Pheromone trap catches of adult moths of *Helicoverpa armigera*

Among the various meteorological variables, the trap catches of *Maruca* adults had positive correlation with maximum (highly significant) (0.620**) and minimum temperature (non-significant) (0.459), whereas, negative and highly significant correlation existed with morning and evening relative humidity (-0.715** and -0.673**) and negative non-significant correlations with rainfall (-0.260) and a positive significant relation with wind velocity (0.555*) during 2018 experimental crop. While in case of *Helicoverpa* male moth catches, maximum temperature (0.645**) showed a highly significant and positive correlation and minimum temperature (significant) (0.565*), whereas, negative and highly significant correlation existed with morning and evening relative humidity (-0.715** and -0.668**) and negative non-significant correlations with rainfall (-0.180) and a highly positive significant correlation with wind velocity (0.679**) (Table 2). The multiple linear regression equation was developed for spotted pod borer and gram pod borer with respect to abiotic factors *i.e.* $Y= - 70.785+ 2.899X_1 - 2.473X_2 -0.253X_3 + 0.572 X_4-0.102X_5 +5.212X_6$ and $Y^1= -72.212 +0.920X_1 +0.660X_2 + 0.268X_3 – 0.392 X_4 - 1.560X_5 +12.029X_6$, respectively. The coefficient of determination ($R^2$) was found to be 0.690 and 0.736 for *Maruca* and *Helicoverpa* respectively for pheromone traps catches on black gram. The overall impact of weather factors on pheromone trap catches of adults spotted pod borer and gram pod borer on black gram was 69.0 and 73.60 per cent, respectively (Table 3).

**Table 2:** Correlation coefficient of mean number of different borer pests on black gram in different types of traps during 2018

| Trap catches | Temperature (⁰ C) | | Relative humidity (%) | | Rainfall (mm) | Wind velocity |
|---|---|---|---|---|---|---|
| | Maximum | Minimum | Morning | Evening | | |
| Adults of *Maruca* | 0.620** | 0.459 | -0.715** | -0.673** | -0.260 | 0.555* |
| Adults of *Helicoverpa* | 0.645** | 0.565* | -0.715** | -0.668** | -0.180 | 0.679** |

**. Significant at the 0.01 level *. Significant at the 0.05 level

**Table 3:** Regression equations and co-efficient of multiple determination ($R^2$) of major insect pests of black gram in relation to abiotic factors

| Trap catches of adults of | Regression linear equations of | Correlation co-efficient (r) | Co-efficient of determination ($R^2$) | Co-efficient of Variation (%) |
|---|---|---|---|---|
| *Maruca* | $Y= - 70.785+ 2.899X_1 - 2.473X_2 -0.253X_3 + 0.572 X_4-0.102X_5 +5.212X_6$ | 0.831 | 0.690 | 69.0 |
| *Helicoverpa* | $Y^1= -72.212 +0.920X_1 +0.660X_2 + 0.268X_3 – 0.392 X_4 - 1.560X_5 +12.029X_6$ | 0.858 | 0.736 | 73.60 |

Where,

Y=Mean No. of Maruca/1 m2 Y1=Mean No. of Helicoverpa/1 m2
X1= Max Temp. X4=RH Evening
X2= Min Temp. X5=Rainfall
X3=RH Morning X6= Wind speed

**Natural enemy fauna on black gram**

During the experimentation, a variety of predatory and parasitic insects, spiders and birds were observed at different stages of its lifecycle and their activities with their respective hosts are presented in Table 4.

A Tachinid fly (*Nemorilla maculosa)*; Predatory Yellow Jacket Wasp; Rove beetle; Coccinellid beetles (*Coccinella septempunctata* and *C. sexmaculata*); Damsel fly*;* Spined soldier bug and different types of spiders such as lycosa spider were recorded as the predominant predatory insects against the spotted pod borer and *Helicoverpa* in black gram ecosystem. Apart from predators, a larval endo-parasitoid, *Campoletis chlorideae* and naturally infected *H. armigera* larvae with the virus (*Ha*NPV) were recovered from the black gram experimental field. The seasonal activity of predatory and parasitiods fauna was commenced 1-3 weeks after the appearance of respective insect pests while activity of pollinator was noticed with the initiation of flowerings.

**Table 4:** Abundance and activity of natural enemy fauna population on black gram

| Natural enemy | Standard weeks | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 |
| Predators | | | | | | | | | | | | | | | | | |
| Lady bird beetle | | | | | | | | | | | | | | | | | |
| Rove beetle | | | | | | | | | | | | | | | | | |
| Damsel fly | | | | | | | | | | | | | | | | | |
| Spined Soldier bug | | | | | | | | | | | | | | | | | |
| Tachanid fly | | | | | | | | | | | | | | | | | |
| Spiders | | | | | | | | | | | | | | | | | |
| *Campoletis chlorideae* | | | | | | | | | | | | | | | | | |
| Stages | Vegetative stage | | | | | | | | | | | | | | | | |
| | Flowering stage | | | | | | | | | | | | | | | | |
| | Pod formation | | | | | | | | | | | | | | | | |

## Discussions

### Trap catches of the adult moths of spotted pod borer, *M. Vitrata* and gram pod borer, *H. armigera*

The present study brought to light that installation of pheromone traps are an efficient tool to ameliorate the larval population density in causing heavy loss to the black gram (Table 1, Fig. 1-2). Anonymous, 2014 [2] followed the practices of installing pheromone traps @ 4-5/acre and replacing the lures with fresh lures after every 2-3 weeks to monitor the moths activity of pod borer complex during vegetative stages of black gram and green gram. The adult activity of the gram pod borer was recorded from the second week of February in Jammu which is in close conformity with Ahmed and Khalique, 2002[1] that the adults started appearing in the crop within first week of March, the peak trap catch population can be observed during fortnight of April and end of trap catch within first week of June in chickpea. A similar trend was reported that the maximum trap catches were obtained due to rise in temperature from the month of February to March (Anwar and Shafique, 1992) [4]. A recent study reported that the installation of 20 traps per acre used to attract the maximum catches of *H. armigera* moths (Madhu *et al*., 2019) [18]. Sagar *et al*., 2017 [29] and Rathore *et al*., 2017[27] reported that the male moth population of gram pod borer had highest significant positive association with maximum and minimum temperature. Furthermore, the moth catches were positively correlated with maximum and minimum temperatures and negatively correlated with relative humidity (Sonkar *et al*., 2012) [32]. In antithetical to our study, Kumar and Durairaj, 2012 [15] reported that the emergence of *H. armigera* adults had a negatively significant correlation with minimum temperature while, other variables (maximum temperature, relative humidity, rainfall and rainy days) had no correlation on *H. armigera* activity. Whereas, the adult activity of *M. vitrata* in present finding showed that the positive significant correlation with maximum and minimum temperature, negative and highly significant with morning and evening relative humidity and positive significant with wind speed and 26.89 moths per trap per week was the highest obtained catches. In contrary to *Helicoverpa armigera*, the limited attempts has been made to carry out the monitoring of pheromone trap catches of adult moths of *M. vitrata* due to differential response to available synthetic blends among its population in Asia and Africa leads to presume that geographically separate populations can exist (Hassan, 2007) [12]. The coherent investigation by Gowda *et al.,* 2015 [10] found that among different combinations, the combination of (Z, E)-10, 12-hexadecadienal; (E, E)-10, 12-hexadecadienol; (Z)-10-hexadecenol and 1-Octen-3-ol (Blend D) at 1000 µg trapped 5.80 ± 1.35 (mean ± S.E) significantly higher mean number of moths per trap in cowpea. Many researchers have reported different numbers of trap catches of *H. armigera* and *M. vitrata* in black gram fields in the antithesis of the present study which may be on account of the influence of variations in geographical conditions and weather factors on pest population.

### Natural enemy fauna on black gram

Results revealed that predatory fauna of borer insect-pest were ample in black gram ecosystem. Besides these, the abounding population of *Campoletis chloridae* is accountable for depressing the swarms of *Helicoverpa armigera* (Table 4). According to Sharma 1998 [31]; Srinivasan *et al.*, 2009 [34] and Ganapathy, 2010 [9], *Nemorilla maculosa* (a tachinid fly) and *Apanteles taragamae* (a braconid wasp) showed good potential to reduce incidences of *Maruca*. *N. maculosa* has been reported to be the parasitoid of several insects in Pyralidae, Tortricidae, Gelechiidae, Scythididae, Hyponomeutidae, and Noctuidae (Lin 2003 [17]; Chen and Luo 2007) [6] and it showed about 40% parasitism of spotted pod borer under laboratory conditions. The ichneumonid, *Campoletis chlorideae* Uchida is known to parasitize 31.4 per cent of larval population of *H. armigera* and thus, makes it the most important parasitoid of gram pod borer on legumes crop in India (Pawar *et al.*, 1986) [22]. Similarly, Tachinids were also reported parasitizing the late-instar *H. armigera* larvae, but result in little reduction in larval density (Sharma *et al.*, 2008) [30]. The study conducted on field survey for natural enemies of *M. testulalis* by Rani *et al.*, 2013 [25] found that *Chilomenus sexmaculata* and ground spiders viz., *Urocteid* species, *Sparassus pseudolamarckii*, *Lycosids*, *Arctosamulani* (Dyal); *Hippasa* spp., *Salticius* spp. were the predominant predators noticed in black gram & green gram ecosystems. *Ha*NPV has been reported to be a viable option to control *H. armigera* in legume crops, without deleterious effects on any other organisms by Rabindra and Jayaraja, 1988[24] and Cherry *et al.*, 2000 [7].

## Conclusion

The extrapolation of this research suggests that, the deployment of pheromone traps in the black gram agro-ecosystem attracted maximum number of adults moth population of Helicoverpa armigera (78.62 moth/trap/week) and Maruca vitrata (26.89 moth/trap/week) under varied weather conditions and meanwhile presence of natural enemies such as predators and parasitoids showed favourable response in minimizing the larval population of gram pod borer and spotted pod borer of region Jammu. The activities of both adult moths were also determined to be greatly influenced by different environmental variables *i.e.*

temperature, relative humidity and wind speed, respectively. The main focus of the present day plant protection in all developing countries are Three R's (resurgence, resistance and residues), so such studies on implying eco-friendly and low cost techniques and exploitation of natural enemies against insect pests' infestation provide an indication to built a timely predicted and region specific integrated pest management modules for the farming community of that region.

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