Population dynamics of pod borer (Helicoverpa armigera HUBNER) infesting oats in relation to abiotic factors

Ritesh Kumar, Ishtiyaq Ahad, Shaheen Gul, Parveena Bano, Sheikh Aafreen Rehman, Qazi Altaf and Stanzin Dorjey

Abstract

Experiment was carried out in the field at the Faculty of Agriculture, Wadura, Kashmir, India during 2015-16 under free choice conditions to Population dynamics of pod borer (Helicoverpa armigera HUBNER) infesting oats in relation to abiotic factors. The results of investigation on population dynamics of pod borer (Helicoverpa armigera HUBNER) on oats revealed that the larval activity appeared from 12th meteorological week with 7.97 larvae/m² and Peak of larval population of H. armigera was recorded 23.26 larvae/m² in 22nd meteorological week. However, adult appeared from 10th meteorological week (2 adults/trap/week) reached its peak 17 adults /trap/week in the 21st meteorological week. Later on, the pest population declined gradually towards the maturity of crop. Correlation of H. armigera adult with different weather parameters indicated that highly significant positive correlation with maximum, minimum temperature and sunshine with their respective values of (r =0.89), (r =0.88) and (r =0.69). However, these adults were highly significant negatively correlated with relative humidity of morning and evening (r = -0.82) and (r = -0.44), respectively. Similarly, the populations exhibited non-significant negative correlation with rainfall (r = -0.13). However, H. armigera larvae exhibited a highly significant positive correlation with maximum temperature (r =0.74), (r =0.92); minimum temperature (r =0.72), (r =0.92) and sunshine (r =0.56), (r =0.69), respectively.

Keywords: Helicoverpa armigera, population dynamics, oats, weather parameters and correlation

1. Introduction

Oats rank sixth in the world cereal production statistics following wheat; maize, rice, barley and sorghum (Pandey and Roy, 2011) [19]. It is mainly cultivated as fodder for animals and also for grain because of its high nutritional and medicinal value. The use of grain is now more focused on mining its benefits as a health food. The importance of oats in the biochemical and cosmetic industry is also on the rise (Tiwari and Cummins, 2009) [20]. Out of cereals, the highest amounts of β-glycan are found in barley and oats grains (Ahmad and Zaffar, 2014) [1]. It is cultivated in Punjab, Haryana, West Bengal, Jammu and Kashmir, Himachal Pradesh, Uttar Pradesh, Madhya Pradesh, Rajasthan and Maharashtra (Pandey and Roy, 2011) [18].

The total area covered under oats cultivation in the country is about 5 lakh ha. The crop occupies maximum area in Uttar Pradesh (34 per cent), followed by Punjab (20 per cent), Bihar (16 per cent), Haryana (9 per cent) and Madhya Pradesh (6 per cent) (Pandey and Roy, 2011) [19]. Various arthropods and nematodes cause damage to oats (Avena sativa L. and A. byzantina K.) plants throughout their life and no stage of the crop is free from damage. Crops can be affected from the seedling stage until the grain is harvested (Southwood and Norton, 1973) [25]. Pest of oats are either polyphagous (damaging a wide range of plants) or oligophagous (feeding on only a few plant species) and it is very rare, any insect found to be monophagous to oats crop. Hundreds of arthropod species feed on oats cultivated in the USA and other countries. Low infestations of certain pests in cereals may stimulate growth and tillers, and actually increase yields (Southwood and Norton, 1973) [25]. The armyworm is one of the most destructive insects infesting oats. It destroys oats in some areas almost every year. Outbreaks are frequently local and sporadic, but occasionally high populations have infested large sections of the eastern USA and Canada (Walkden, 1950) [30]. Damage to oats in 1954 was estimated to be over $5 million (USA); an estimated $12 million (USA) loss was prevented with insecticides.

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In Jammu and Kashmir Lone et al. [16] reported armyworm *Mythimna separata* major pest in the state which caused heavy losses in the oats which is grown only for fodder purpose. *Helicoverpa armigera* (Hubner) (Lepidoptera: Noctuidae), is well known as cotton bollworm, gram caterpillar, pod borer or American bollworm. It is highly polyphagous pest with broad spectrum of host families including important agriculture crop such as cotton, chickpea, pigeon pea, sorghum, sunflower, cotton, soybean, groundnut, even wheat etc. (Fitt, 1989) [7]. These characteristics make *H. armigera* particularly well adapted to exploit transient habitats, such as man-made ecosystems. Worldwide, *H. armigera* has been reported on over 180 cultivated hosts and wild species in at least 45 plant families (Venette et al., 2003) [28]. The larvae feed mainly on the flowers and fruit of high value crops, and thus high economic damage can the flowers and fruit of high value crops, and thus high economic damage can be caused at low population densities (Anonymous, 2007) [3]. It is considered as the most damaging insect pests in Australian agriculture, costing approximately $225.2 million per year to control (Clearly et al., 2006) [8]. This pest is considered as a major insect pest of both field and horticultural crops in many parts of the world (Fitt, 1989) [7]. The pest status is due to its broader host range of its larvae, its feeding preference for reproductive stages of plants; its high fecundity; its high mobility; and its ability to enter facultative diapauses and thus adapt to different climates (Clearly et al., 2006) [3]. Upadhyay et al. (1989) [27] conducted Experiment to study the impact of weather parameters on larval populations of *H. armigera* on groundnut revealed that *H. armigera* population showed a positive association with maximum temperature and minimum temperature as well as relative humidity. James et al. (1986) [11] showed that 32.2°C is upper limit to shoot bugs in summer count was lower as compare to winter; to bearing the temperature shoot bug are preferring moist place on maize plant viz. whors, leaf sheath, downside of leaf etc. Keeping in view the above facts it becomes imperative to study the Population Dynamics of Pod Borer (*H. armigera* HUBNER) Infesting Oats in Relation to Abiotic Factors.

2. Materials and Methods
Oats variety “Sabzar” was raised during the Rabi season in 2015-16 under the recommended package of practices of SKUAST-Kashmir at Faculty of Agriculture, Wadura. Observations were recorded at weekly intervals to know the Population Dynamics of Pod Borer (*H. armigera* HUBNER) Infesting Oats in Relation to Abiotic Factors. After sowing of oats in the last week of November, white snow carpet remains over the crop during December-February. Oats variety “Sabzar” was planted at 22.5 cm spacing in 3 x 4 m plot size. The experimental plot was maintained without application of any insecticides. Crop was raised in natural conditions (i.e. without any application of insecticides) to allow population buildup of insect pests.

Adult activity: It is established fact that visible light attracts a wide range of insects and in the management part this has led to the development of various forms of light traps. It offers an efficient means of obtaining information regarding the distributions, seasonal flight periods and peak of abundance of various insect species, thereby helping in the suppression of pest through suitable plant protection measures at appropriate time. Hence, investigations were carried out to determine the seasonal population fluctuations of adults through light trap and climatic factors influencing them. To achieve this objective, a multi directional light trap was operated from 18.00 to 6.00 hours daily. The collections were made weekly throughout the experiment. Number of adults on the basis of weekly catches were correlated with the abiotic factors (temperature, sunshine, relative humidity and rainfall).

Larval activity: Larval activity was determined by counting the total number of larvae at weekly interval. To assess the larval populations at experimental sites, square meter/quadrant method was done within the experimental plots. Larvae registered in the experiment were correlated with the abiotic factors (temperature, relative humidity, sunshine and rainfall) and biotic factor (HaNPV).

Meteorological data: Data on temperature (Max. / Min. in °C), sunshine (hrs.) relative humidity (%) and rainfall (mm) was collected from automatic weather station, Wadura. Multiple correlations were worked out to determine the cumulative and individual effects of weather factors (temperature, sunshine, rainfall and relative humidity) on population buildup of the insect pests.

Statistical analysis: Data collected from the experimental site was subjected to standard statistical procedure using standard statistical procedures (Gomez and Gomez, 1984) [9].

3. Results and Discussion
3.1 Population Dynamics of Pod Borer (*H. armigera* HUBNER)
The data presented in (Table 1 & Fig 2, 3) showed that the adult activity of *H. armigera* on oats crop was commenced from regular occurrence and caused considerable damage in the field. Light trap catches of adults of *H. armigera* appeared from 10th meteorological week (2 adults/trap/week) and continued up to 27th meteorological week during the year. The population increased gradually, reached its peak 17 adults /trap/week in the 21st meteorological week. Thereafter the population showed declined trend with increase in temperature. However, neither of the adult of *H. armigera* were caught in light trap during 47, 48, 49, 50, 51, 52, 1, 2, 3, 4, 5, 6, 7, 8 and 9th meteorological weeks due to the snow carpet in the field. Mahapatra et al. (2007) [17] observed higher number of moths trapped during March and April months. Present findings were contradictory with Anonymous (1988) [21] who reported that incidence of *H. armigera* commenced during mid-January, increased gradually in the month of February and reached on peak at the end of March, then decreased rapidly within two weeks onward. Contradiction between the results might be due to difference in the climatic condition as Kashmir weather is freezing in January and February and insects remain in hibernation during the said season. The larvae of *H. armigera* fluctuated throughout the growing season, it commenced its activity from 12th meteorological week with 7.97 larvae/m². Peak of larval population of *H. armigera* was recorded 23.26 larvae/m² in 22nd meteorological week thereafter, it showed declining trend as crop progressed to maturity. Death of larvae due to HaNPV appeared from 13th meteorological week (2.57 larvae/ m²) which reached its maximum in the peak 24th meteorological week (7.87 larvae/ m²). There was decline in the mortality due to infection of HaNPV of this pest with increase in temperature (Table 1 & Fig.2&3). Many laboratory studies have demonstrated that nucleopolyhedrovirus is inactivated by exposure to high temperature. Leed et al. (1977) [15] stated that increase in temperature from 15 to 45°C
increased the LD₅₀ values of *H. zea* NPV (29.8-349.2 POB mm² of diet surface). Johnson et al. (1982) [11] demonstrated the inhibition of virus activity against the velvet bean caterpillar, *Anticarsia gemmatalis*, at the extremes of temperature of 10 and 40°C. Kelly and Entwistle (1988) [12] found an approximate linear relationship between the *Mamestra brassicae* NPV and incubation temperature. Histopathological studies by Sathaiyal (2001) [22] revealed that 25°C, the growth of fat body in virus-inoculated larvae progressed normally during the early stages of infestation providing adequate substrate for the growth and multiplication of virus. In *H.armigera* larvae, the virus multiplied at a slow pace at 25°C allowing the fat bodies to proliferate simultaneously. At higher temperatures the virus multiplied faster destroying the fat body before it could grow to provide greater the fat body before it could grow to provide greater substrate volume. Therefore, a good mass production facility should possess a temperature-controlled incubation chamber to provide a constant temperature of 25±1 °C. Almost similar kind of observations were observed by Shah and Shahzad (2005) [23], who reported its low population during 49th to 6th standard weeks but increased from 7th standard week onwards and declined again during 14th standard week. Anwar et al. (1994) [4] also reported high larval population during February and March. Growing/multiplication season in Kashmir commences late i.e April due to low temperatures below 15°C during day and nights are freezing hence, variation in insect population may occur because of variation in climatic conditions.

3.2. Correlation studies of adult population of *H. armigera* with important abiotic factor parameters

Correlation between meteorological factors and *H. armigera* adult population revealed that the population exhibited a highly significant positive correlation with maximum, minimum temperature and sunshine with their respective values of (r =0.89), (r =0.88) and (r =0.69). However, these adults were highly significant negatively correlated with relative humidity of morning and evening (r = -0.82) and (r =-0.44), respectively. Similarly, the populations exhibited non-significant negative correlation with rainfall (r = -0.13) (Table 2). Similar kind of observations were also recorded by Rothchild et al. (1981) [12], Yadav and Lal (1988) [13], Deshpande and Khan (1990) [6]; Yadav et al. (1991) [12], Venkataiah and Subbaratnam (1992) [28]; Lal (1996) [14], Gour (1997) [10]; Ganguli et al. (1998) [8] and Metange et al. (2004) [18].

3.3. Correlation studies of larval population with important abiotic factor parameters

It is evident from the data that, *H. armigera* larvae and its infected larvae due to HaNPV exhibited a highly significant positive correlation with maximum temperature (r =0.74), (r =0.92); minimum temperature (r =0.72), (r =0.92) and sunshine (r =0.56), (r =0.69), respectively. Moreover, both of the populations (healthy and infected) exhibited significant negative correlation with the relative humidity of morning with respective values of (r = -0.66) and (r = 0.86) however, normal/healthy larvae showed non-significant results with evening relative humidity. Infected larvae exhibited significant negative correlation with relative humidity of evening. On the other hand both larvae exhibited non-significant results with rainfall. (Table 2). Our results are in close agreement with Sharma et al. (2012) [24] who reported that abiotic factors like maximum temperature and minimum temperature had positive correlation with male moth catches and larval population of *H. armigera* while, relative humidity had negative correlation with male moth catches and larval population of *H. armigera*. Reddy et al. (2009) [20] recorded larval abundance of *H. armigera* and reported non-significant correlations with temperature (°C), R.H. (%) and rainfall, sunshine, wind speed at Allahabad.

4. Conclusions

Based on the result, it can be concluded that chickpea pod borer adult (*H.armigera* Hubner) commenced from 10th meteorological week (2 adults/trap/week) and continued up to 27th meteorological week during the year. The population increased gradually, reached its peak 17 adults /trap/week in the 21th meteorological week. Thereafter the population showed declined trend with increase in temperature. Larval activity start from 12th meteorological week with 7.97 larvae/m². Peak of larval population of *H. armigera* was recorded 23.26 larvae/m² in 22nd meteorological week thereafter, it showed declining trend as crop progressed to maturity. Correlation between meteorological factors and *H. armigera* adult population revealed that the population exhibited a highly significant positive correlation with maximum, minimum temperature and sunshine. However, these adults were highly significant negatively correlated with relative humidity of morning and evening. Similarly, the populations exhibited non-significant negative correlation with rainfall. *H. armigera* larvae and its infected larvae due to HaNPV exhibited a highly significant positive correlation with maximum temperature, minimum temperature and sunshine. Moreover, both of the populations (healthy and infected) exhibited significant negative correlation with the relative humidity of morning. However, normal/healthy larvae showed non-significant results with evening relative humidity. Infected larvae exhibited significant negative correlation with relative humidity of evening. On the other hand both larvae exhibited non-significant results with rainfall.

5. Acknowledgement

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<table>
<thead>
<tr>
<th>Standard week</th>
<th><em>H. armigera</em></th>
<th>Infestation of larvae due to HaNPV</th>
<th>Temperature (°C)</th>
<th>Rainfall/week (mm)</th>
<th>Relative Humidity (%)</th>
<th>Sun shine (hr.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>47th</td>
<td>0.00</td>
<td>0.00</td>
<td>Max. 15.21</td>
<td>Min. 0.21</td>
<td>0.00</td>
<td>Morni-ng 90.43</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>72.57</td>
<td>Eveni-ng 66.71</td>
</tr>
<tr>
<td>48th</td>
<td>0.00</td>
<td>0.00</td>
<td>Max. 12.07</td>
<td>Min. 0.14</td>
<td>0.14</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>89.14</td>
</tr>
<tr>
<td>49th</td>
<td>0.00</td>
<td>0.00</td>
<td>Max. 12.85</td>
<td>Min. -1.94</td>
<td>0.00</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>87.29</td>
<td>62.57</td>
</tr>
<tr>
<td>50th</td>
<td>0.00</td>
<td>0.00</td>
<td>Max. 7.71</td>
<td>Min. 0.41</td>
<td>3.11</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>87.29</td>
<td>76.57</td>
</tr>
</tbody>
</table>
Table 2: Correlation between weather parameters and population of *H. armigera*

<table>
<thead>
<tr>
<th>Factors</th>
<th>Correlation coefficient (r)</th>
<th>Regression Equation</th>
<th>Correlation coefficient (r)</th>
<th>Regression Equation</th>
<th>Correlation coefficient (r)</th>
<th>Regression Equation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max.</td>
<td>0.74**</td>
<td>Y= -4.48+0.696 X</td>
<td>0.92**</td>
<td>Y= -3.59+0.330X</td>
<td>0.89**</td>
<td>Y= -7.32+0.669 X</td>
</tr>
<tr>
<td>Min.</td>
<td>0.72**</td>
<td>Y= 4.49+0.824 X</td>
<td>0.92**</td>
<td>Y=0.599+0.402X</td>
<td>0.88**</td>
<td>Y= 1.26+ 0.798 X</td>
</tr>
<tr>
<td>Relative humidity (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Morning</td>
<td>-0.66**</td>
<td>Y= 71.3+(0.736) X</td>
<td>-0.86**</td>
<td>Y=33.74(-0.365)X</td>
<td>-0.82**</td>
<td>Y=67.14(-0.725) X</td>
</tr>
<tr>
<td>Even.</td>
<td>-0.28 NS</td>
<td>Y= 18.7+(0.178) X</td>
<td>-0.40*</td>
<td>Y=8.044(-0.0958)X</td>
<td>-0.44**</td>
<td>Y= 18.04(-0.223) X</td>
</tr>
<tr>
<td>Sun shine (hr.)</td>
<td>0.56**</td>
<td>Y=0.28+1.59 X</td>
<td>0.60**</td>
<td>Y= -1.27+0.737</td>
<td>0.69**</td>
<td>Y= -2.83+ 1.59 X</td>
</tr>
<tr>
<td>Rainfall/week (mm)</td>
<td>0.15 NS</td>
<td>Y=7.52+0.376 X</td>
<td>-0.15 NS</td>
<td>Y=2.83+0.147X</td>
<td>-0.13 NS</td>
<td>Y= 5.62+(-0.259) X</td>
</tr>
</tbody>
</table>

NS= Non-significant (P>0.05); *, Significant (P<0.05); **, highly significant (P<0.01)

Fig 1: Population of *Helicoverpa armigera* (adult and larval activity) along with weather parameters
6. References


