International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2018; 6(4): 2792-2797

Received: 16-05-2018
Accepted: 21-06-2018

Ritesh Kumar
Division of Entomology, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Wadura, Sopore, Kashmir, India

Ishtiyaq Ahad
Division of Entomology, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Wadura, Sopore, Kashmir, India

Shaheen Gul
Division of Entomology, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Wadura, Sopore, Kashmir, India

Parveena Bano
Division of Entomology, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Wadura, Sopore, Kashmir, India

Sheikh Aafreen Rehman
Division of Entomology, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Wadura, Sopore, Kashmir, India

Qazi Altaf
Division of Horticulture, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Wadura, Sopore, Kashmir, India

Stanzin Dorjey
Division of Plant Pathology, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Wadura Sopore, Kashmir, India

Correspondence
Ritesh Kumar
Division of Entomology, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Wadura, Sopore, Kashmir, India

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/m^2 and Peak of larval population of *H. armigera* was recorded 23.26 larvae/m^2 in 22nd meteorological week. However, adult appeared from 10th meteorological week (2 adults/trap/week) reached its peak 17 adults /trap/week in the 21th 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 = -S0.82) 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) [26]. 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) [19].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. byzantino* 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]. Pests 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.

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) [5]. 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 (Cleary *et al*., 2006) [5]. 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 32.2ºC 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*. whorls, 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 ^{0}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 21th 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)[2] 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/m^2. Peak of larval population of *H. armigera* was recorded 23.26 larvae/m^2 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/ m^2) which reached its maximum in the peak 24th meteorological week (7.87 larvae/ m^2). 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. Leod *et al.* (1977) [15] stated that increase in temperature from 15 to 45ºC increased the LD_{50} values of *H. zea* NPV (29.8-349.2 POB mm^{-2} 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 40ºC. Kelly and Entwistle (1988) [13] found an approximate linear relationship between the *Mamestra brassicae* NPV and incubation temperature. Histopathological studies by Sathiah (2001) [22] revealed that 25ºC, 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 25ºC 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 ºC. 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 15ºC 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 Rothschild *et al*. (1981) [21]; Yadav and Lal (1988) [31]; Deshpande and Khan (1990) [6]; Yadav *et al*. (1991) [32]; Venkataiah and Subbaratnam (1992) [29]; 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 (ºC), 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/m^2. Peak of larval population of *H. armigera* was recorded 23.26 larvae/m^2 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

Authors are thankful to Dean (Agriculture), Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Wadura, Sopore, for providing the necessary facilities and support for carrying out the study successfully.

Table 1: Population dynamics of *H. armigera* (Hub.) on oats crop

Standard week	*H. armigera*		Infestation of larvae due to HaNPV	Temperature (°C)		Rainfall/week (mm)	Relative Humidity (%)		Sun shine (hr.)
	No. of adults/trap/ week	No. of Larvae/ m^2		Max.	Min.		Morni-ng	Eveni-ng	
47th	0.00	0.00	0.00	15.21	0.21	0.00	90.43	72.57	3.64
48th	0.00	0.00	0.00	12.07	0.14	0.14	89.14	66.71	1.71
49th	0.00	0.00	0.00	12.85	-1.94	0.00	87.29	62.57	2.87
50th	0.00	0.00	0.00	7.71	0.41	3.11	87.29	76.57	0.00

51ist	0.00	0.00	0.00	8.50	-4.01	0.00	90.29	66.71	4.10
52nd	0.00	0.00	0.00	6.75	-3.28	0.17	89.86	65.86	1.83
1st	0.00	0.00	0.00	8.14	-1.07	2.54	91.71	74.00	1.50
2nd	0.00	0.00	0.00	8.71	-3.01	0.60	92.29	72.14	2.53
3rd	0.00	0.00	0.00	11.71	-4.41	0.00	92.86	50.71	5.79
4th	0.00	0.00	0.00	11.57	-3.28	0.17	92.14	46.29	4.80
5th	0.00	0.00	0.00	13.31	-1.78	0.00	90.14	42.14	6.46
6th	0.00	0.00	0.00	9.64	-0.65	3.40	91.43	60.00	2.19
7th	0.00	0.00	0.00	13.21	-0.58	4.37	88.29	52.71	5.80
8th	0.00	0.00	0.00	21.07	-0.97	0.00	99.14	34.57	9.66
9th	0.00	0.00	0.00	18.05	1.21	0.57	85.71	42.14	4.47
10th	2.00	0.00	0.00	14.35	3.62	6.01	86.29	63.86	2.96
11th	4.00	0.00	0.00	10.14	1.84	16.62	92.00	75.43	2.26
12th	4.00	7.97	0.00	15.28	3.14	4.54	84.43	64.29	3.97
13th	6.00	9.25	2.57	14.18	7.11	4.75	91.57	81.71	0.37
14th	7.00	11.38	3.13	18.21	5.77	4.80	90.29	68.57	5.33
15th	9.00	16.25	3.46	19.42	7.48	5.02	88.29	70.00	3.60
16th	8.00	14.54	4.45	20.28	4.42	2.10	85.43	64.29	7.17
17th	11.00	17.58	4.96	23.57	8.21	1.62	80.86	58.29	5.79
18th	15.00	17.34	4.85	25.21	9.64	1.64	81.29	54.71	5.53
19th	13.00	16.56	5.87	29.14	10.21	1.71	76.29	43.14	8.56
20th	10.00	21.57	5.67	27.14	11.35	3.82	80.00	54.43	7.63
21st	17.00	21.51	6.90	30.21	12.54	0.00	70.43	39.86	9.83
22nd	16.00	23.26	6.93	28.92	13.05	0.48	74.86	44.00	9.07
23rd	15.00	16.59	7.84	30.21	15.48	0.08	78.29	49.57	7.61
24th	10.00	13.54	7.87	31.42	14.84	0.00	69.14	54.86	8.80
25th	12.00	11.68	6.86	32.00	16.18	0.80	76.86	41.57	10.10
26th	10.00	7.91	6.85	31.00	16.91	0.85	75.86	47.43	6.41
27th	9.00	3.51	4.13	29.35	16.71	4.94	81.71	50.29	6.33

Table 2: Correlation between weather parameters and population of *H. armigera*

Factors	Larvae		Infested larvae due to HaNPV		Adult	
	Correlation coefficient (r)	**Regression Equation**	**Correlation coefficient (r)**	**Regression Equation**	**Correlation coefficient (r)**	**Regression Equation**
Temperature (°C)						
Max.	0.74**	Y= -4.48+0.696 X	0.92**	Y= -3.59+0.330X	0.89**	Y= -7.32+0.669 X
Min.	0.72**	Y= 4.49+0.824 X	0.92**	Y=0.599+0.402X	0.88**	Y= 1.26+ 0.798 X
Relative humidity (%)						
Morning	-0.66**	Y= 71.3+ (0.736) X	-0.86**	Y=33.7+(-0.365)X	-0.82**	Y=67.1+(-0.725) X
Evening	-0.28 NS	Y= 18.7+ (0.178) X	-0.40*	Y=8.04+(-0.0958)X	-0.44**	Y= 18.0+(-0.223) X
Sun shine (hr.)	0.56**	Y= 0.28+ 1.59 X	0.69*	Y= -1.27+0.737	0.69**	Y= -2.83+ 1.59 X
Rainfall/week (mm)	0.15 NS	Y=7.52+ 0.376 X	-0.15 NS	Y=2.83+(-0.147)X	-0.13 NS	Y= 5.62+ (-0.259) X

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

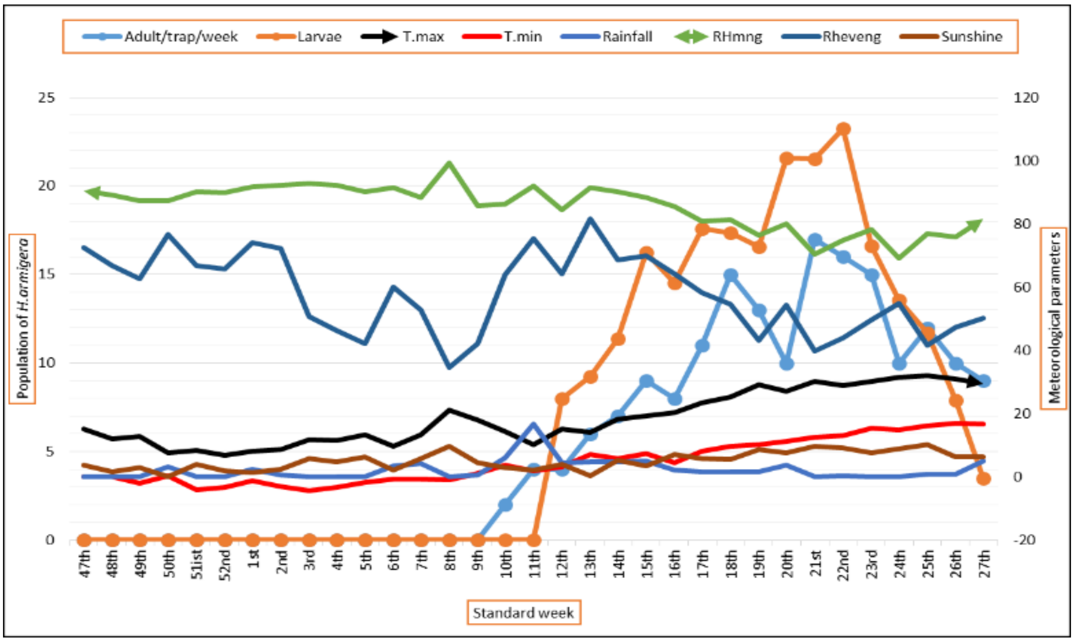

Fig 1: Population of *Helicoverpa armigera* (adult and larval activity) along with weather parameters

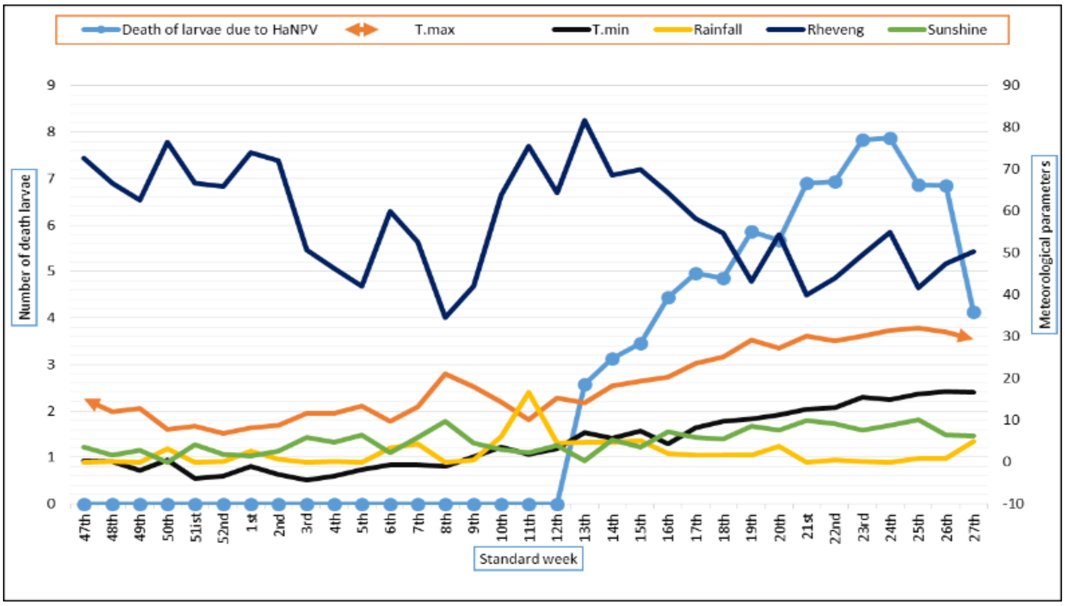

Fig 2: Population of death of larvae due to HaNPV along with weather parameter

6. References

1. Ahmad M, Zaffar G. Evaluation of oats (*Avena sativa* L.) genotypes for beta-glucan, grain yield and physiological traits. Applied Biological Research. 2014; 16(1):1-3.
2. Anonymous. Final progress report (1984-1987), ICAR scheme on determination of economic threshold levels and off season bio-ecology of important insect pests of pulses. Department of Entomology, RCA, Udaipur (India). 1988, 30-32.
3. Anonymous. CABI: Crop Protection Compendium. Commonweath Agricultural Bureau, International. 2007. http://www.cabicompendium.org/
4. Anwar M, Shafique M, Ahmad M, Shaloori AP. Incidence of attack and population fluctuation of *Heliothis armigera* in relation to chickpea phenology and environmental factors. Proceedings of Pakistan Congress of Zoology. 1994, 12.
5. Cleary AJ, Cribb BW, Murray DAH. *H. armigera* (Hubner): can wheat stubble protect cotton from attack. Australian Journal of Entomology. 2006; 45:10-15.
6. Deshpande RR, Khan L. Moth catches in pheromone traps in relation to meteorological conditions. Journal of Cotton Research and Development. 1990; 4(1):93-99.
7. Fitt GP. The ecology of *Heliothis* species in relation to agro ecosystems. Annual Review of Entomology. 1989; 34:17-52.
8. Ganguli RN, Dubey VK, Yadu YK. Studies on population dynamics of *H. armigera* based on light trap catches in Chhattisgarh region of Madhya Pradesh. Abstract in Entmology in 21st century, 1998; 30th-2nd: 257.
9. Gomez KA, Gomez AA. Statistical Procedures for Agricultural Research. An International Rice Research Institute. 2nd edition. Wiley-Inter Science Publication, New York, 1984, 680.
10. Gour IS. Management of major pests of tomato, *Lycopersicum esculentum* Mill. During summer. M.sc. (Ag.) Thesis, S.K.N. college of Agriculture, RAU, Bikaner, 1997.
11. James H, Sai T, Stephen W. Wilson Biology of *Peregrinus maidis* with Descriptions of immature stages (Homoptera:Delphacidae). Annals Entomological Society of Ametica. 1986; 79:395-401.
12. Johnson DW, Boucias DB, Barfield CS, Allen GE. A temperature-dependent developmental model for a nuclear polyhedrosis virus of the velvet bean caterpillar, *Anticarsia gemmatalis* (Lepidoptera: Noctuidae). Journal of Invertebrate Pathology. 1982; 40:292-298.
13. Kelly PM, Entwistle PF. *In vivo* mass production in cabbage moth (*Mamestra brassica*) of a heterologous (*Panolis*) and a homologus (*Mamestra*) nuclear polyhedrosis virus. Journal of Virology. 1988; 25:93-100.
14. Lal, OP. An outbreak of pod borer, *H. armigera* on chickpea in eastern Uttar Pradesh. Journal Entomology Research. 1996; 20:179-181.
15. Leod MCPJ, Yearian WC, Young SY. Inactivation of Baculovirus Heliothis by ultraviolet irradiation, dew and temperature. Journal of Invertebrate pathology. 1977; 30:237-241.
16. Lone GM, Baba ZA, Wani NA, Mir SA, Malik MA, Parveena B. Determination of pest complex of oats *Avena sativa* (L.) var. Kent and their status. Indian Journal of Applied Entomology. 2009; 23(2):140-144.
17. Mahapatra SD, Aswal JS, Mishra PN. Monitoring population dynamics of tomato fruit borer, *H. armigera* Hubner moths through pheromone traps in Uttaranchal Hills. Indian Journal of Entomology. 2007; 69(2):172-173.
18. Metange KK, Khandge SV, Upadhyay AP, Agrawal KK. Influence of temperature on incidence of gram pod borer *H. armigera* Hubner. Indian Journal of Entomology. 2004; 66(3):272-274.
19. Pandey KC, Roy AK. Forage Crops Varieties. IGFRI Jhansi (India), 2011, 16-17.
20. Reddy V, Anandhi P, Eamathi S, Varma S. Seasonal occurrence of pulse pod borer, *H. armigera* (Hub.) on chickpea at eastern U.P. region. Agriculture Science Digest. 2009; 29:60-62.
21. Rothschild GHL, Wilson ACL, Malafant KW. Preliminary studies on the female sex pheromones of *Heliothis* sp. and their possible use in control programme in Australia. Proceedings of International workshop on Heliothis management, ICRISAT, Centre, Patancheru, India, 1981.

22. Sathiah N. Studies on improving production and formulation of the nuclear polyhedrosis virus of cotton bollworm *H. armigera* (Hubner), 2001.
23. Shah ZA, Shahzad MK. Population fluctuations with reference to different developmental stages of *H. armigera* (Lepidoptera: Noctuidae) on chickpea and their relationship with the environment. International Journal of Agriculture and Biology. 2005; 7:90-93.
24. Sharma PK, Kumar U, Vyas S, Sharma S, Surabhi S. Monitoring of *H. Armigera* (Hubner) (Lepidoptera: Noctuidae). Through Pheromone Traps in Chickpea (*Cicer Arietinum*) Crop and Influence of Some Abiotic Factors on Insect Population. Journal of Environmental Science, Toxicology and Food Technology, 2012, 44-46.
25. Southwood TRE, Norton GA. Economic aspects of pest management strategies and decisions. In: P.W. Geier *et al*., (ed.) Insects: Studies in population management. Ecological Society of Australia, Canberra, Australia, 1973, 168-184.
26. Tiwari U, Cummins E. Simulation of the factors affecting B-glucan levels during the cultivation of Oats. Journal of Cereal Sciences. 2009; 50:175-183.
27. Upadhyay VR, Vyas HN, Sherasiya RA. Influence of weather parameters on larval populations of *Heliothis armigera* Hubner on groundnut. Indian Journal of Plant Protection. 1989; 17(1):85-87.
28. Venette R, Davis CEE, Zaspel J, Heisler H, Larson M. Mini Risk Assessment Old World bollworm, *Helicoverpa armigera* Hubner [Lepidoptera: Noctuidae]. Cooperative Agricultural Pest Survey, Animal and Plant Health Inspection Service, US Department of Agriculture, 2003.
29. Venkataiah M, Subbaratnam GV. Influence of weather factors on the abundance of *H. armigera* (Hubner). Indian Journal of Ecology. 1992; 19(1):55-60.
30. Walkden HH. Cutworms, armyworms and related species attacking cereal and forage crops in the Central Great Plains. USDA Circular. 849. U.S. Government Printing Office, Washington, DC, 1950.
31. Yadav CP, Lal SS. Relationship between certain abiotic and biotic factors and occurrence of gram pod borer, *Heliothis armigera* (Hub.) on chickpea. Entomon. 1988; 13(3-4):269-273.
32. Yadava CP, Lal SS, Ahmad R, Sachan JN. Influence of abiotic factors on relative abundance of pod borers of chickpea (*Cicer arietinum*). Indian Journal of Agriculture Science. 1991; 61(7):512-515.