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Population dynamics of gram pod borer (*Helicoverpa armigera* Hubn.) in relation to abiotic factors on field pea

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Abstract
To study the seasonal incidence of gram pod borer in field pea ecosystem four experiments were conducted at Research Farm of Bidhan Chandra Krishi Viswavidyalaya, Mohanpur during rabi seasons of 2015-16 to 2018-19. The study revealed that the infestation of this pest was highly influenced by different weather parameters. The activity of larval population started in the field from 2nd, 3rd or 4th SMW in different seasons.*H. armigera* population reached its peak during last week of January in 2017-18 at flowering stage and rest of the years in mid of February at pod maturity stage of the crop. Among the meteorological parameters taken into consideration maximum temperature, minimum temperature and bright sunshine hour had positive correlation with the pod borer population while maximum and minimum relative humidity showed negative correlation with the pest population. The multiple regression equation revealed that variations of different weather parameters caused approximately 64 to 88 percent variations in gram pod borer population in four seasons. These meteorological parameters determine the seasonal incidence gram pod borer in field pea and this information may be helpful to develop ecofriendly pest management practices.

Keywords: Gram pod borer, *Helicoverpa armigera*, population dynamics, field pea, weather parameters, correlation.

Introduction
Field Pea (*Pisum sativum* Linn.) is a highly nutritive legume which contains almost 25.5-39.7% protein (Davies *et al*., 1985) [5]. Pea was probably domesticated in the Middle East, simultaneously with wheat and barley, not later than the sixth millennium BC (Zohary and Hopf, 1973) [23]. In India field pea is cultivated over an area of 11.50 L ha with the production of about 10.36 LT during 12th Plan period (Anon. 2016) [2]. Various pest and disease cause damage to pea crop from seedling stage to harvest. Among various biotic constraints, gram pod borer, *Helicoverpa armigera* Hubn. Attack is a major limiting factor for the production of pea (Singh *et al*., 2010) [16]. Gram pod borer is recorded as one of the most serious pest of pulses (Soundararajan and Chitra, 2012) [19]. Its population peaks generally correspond to the flowering and pod formation stage of the crop. The major problems of this pest are its nocturnal behavior, polyphagous in nature, voracious feeding habits on flowers and pods, higher mobility of larval population, high fecundity, multi-voltine nature, overlapping generations etc. (Sarode, 1999) [15]. World-wide it has been reported on over 180 cultivated hosts and wild species in at least 45 plant families (Venette *et al*., 2003) [21]. Different weather parameters have a profound influence on seasonal appearance, growth and development of *H. armigera*. Abiotic factors like variation in temperature and relative humidity (Yadava *et al*., 1991) [22] affect the incidence of pod borers. Keeping in view the above facts the present experiment was conducted to study the incidence of *H. armigera* on field pea and to find out their correlation with the prevailing weather parameters.

Materials and Methods
The field experiment were conducted at 'A-B' Block Farm of Bidhan Chandra Krishi Viswavidyalaya, Kalyani, Nadia, West Bengal during *rabi* seasons of four consecutive years starting from 2015-16 to 2018-19. The seeds of field pea var. Rachna were sown on first week

of December in all seasons with a plot size of 10 m x 10 m and maintaining row to row and plant to plant spacing of 30 cm and 10 cm, respectively. The fields were completely kept free from any pesticides application. All the recommended agronomic practices including application of fertilizers, intercultural operations like gap filling, thinning and hand weeding were adopted. Observations were recorded at seven days intervals from three weeks after sowing (WAS) and continued up to harvesting of the crop to study the population dynamics of the pest. For taking weekly observations ten plants were selected randomly from each plot and visual observations were taken by counting the number of pod borer larvae per plant and afterwards mean was calculated. The daily weather parameters viz. temperature (maximum and minimum), relative humidity (maximum and minimum), wind speed, bright sunshine hours were collected from AICRP on Agro-meteorology, Directorate of Research, BCKV. Then the weather data were converted into weekly basis against different standard meteorological week (SMW) corresponding to weekly population of gram pod borer and correlated with each other. Significance of correlation coefficients was estimated by using t-test and linear multiple regression equations were derived (Gomez and Gomez, 1984) [6]. For making the regression equations the weekly population of gram pod borer was considered as dependent variable and corresponding weekly weather parameters as independent variables.

Results and Discussions

Population dynamics of gram pod borer

Seasonal incidences of gram pod borer (*H. armigera*) during 2015-16 to 2018-19 were presented in Tables and Figures 1-4, respectively. The data revealed that larval population of gram pod borer were fluctuated throughout the crop growing season. During first year the larval population commenced its activity from 4th standard meteorological week (SMW) i.e. on 22nd January at flowering stage of the crop with 0.4 larvae/ plant. Peak of larval population i.e. 2.3 larvae/ plant was recorded at pod maturity stage of crop on 8th SMW when maximum temperature was 31.43°C, minimum temperature was 16.67°C, maximum relative humidity was 92.41%, minimum relative humidity was 60.27%, wind speed was 0.25 km/ h, bright sunshine hour was 7.84 hours. Thereafter, the pest population showed declining trend as crop progressed to maturity. During 2016-17, also first appearance of gram pod borer was recorded in 4th SMW with its initial density of 0.2 larvae/ plant. The intensity of gram pod borer was increasing gradually in ensuing weeks with the initiation of pod formation. Highest larval population (4.2 larvae/ plant) was noticed on 22nd January (8th SMW) when the pods were matured and thereafter the population declined rapidly. During 2017-18, the larval population started to build up from second week of January (2nd SMW) and ranged from 0.2 to 6.6 larvae/ plant in whole crop growing season. The population increased gradually from 0.2 to 6.6 larvae with the increase of maximum and minimum temperature. Maximum larval population (6.6 larvae/ plant) was noticed on 5th SMW at full blooming stage of the crop when maximum temperature was 32.29°C, minimum temperature was 11.29°C, maximum relative humidity was 90.71%, minimum relative humidity was 45.43%, wind speed was 0.26 km/h, bright sunshine hour was 8.03 hours. The pest population steadily declined thereafter with the maturation of crop. During 2018-19, activity of *H. armigera* was commenced from third week of January (3rd SMW) with its initial population of 1.8 larvae/ plant. The larval population gradually increased, in general and there was a steep rise in the level of 6.4 larvae/ plant recorded during 2nd week of February at pod maturity stage and thereafter, the population suddenly reduced in spite of further increase in the temperature which may be due to the crop maturity.

The result of the present study can be compared with the findings of Ravi and Verma (1997) [13], who reported the incidence of gram pod borer on chickpea in first week January and reached its peak in March. Antithetical to present study, Patel and Koshiya (1999) [9] reported that *Helicoverpa armigera* population was first observed in the third week of November and reached a peak in the third week of December at pod formation stage of chickpea in Gujarat condition which probably may be due to the shift in *Helicoverpa* population to cotton, another major host crop of the pest. However, the present findings are in accordance with the findings of Singh *et al*. (2005) [18] who recorded minimum intensity of pod borer in vegetative phase as comparison to maximum population during reproductive phase in chickpea and they also found that the pest population reached its second peak during mid of February. The present findings are more or less in support with Chatar *et al*. (2010) [4] regarding the seasonal incidence of gram pod borer from 2nd week of December to 3rd week of January and decline in population gradually towards the maturity of the crop. The present finding is in conformity with Ramesh Babu *et al*. (2009) [11] who observed the maximum pod borer population on chickpea during 8th and 9th SMW in Banswara, Rajasthan. Ahmed and Khalique (2002) [1] also found the maximum activity of gram pod borer in chickpea on second week of February in Jammu.

Table 1: Population dynamics of *H. armigera* (Hub.) on field pea during 2015-16

Date of observation	SMW	Crop stage	No. of pod borer larvae/ plant	Temperature (°C)		RH (%)		Wind speed (Km/h)	Bright Sunshine Hour (h)
				Max.	Min.	Max.	Min.		
24.12.15	52	Vegetative	0.0	26.61	14.24	93.54	58.32	0.21	7.21
01.01.16	1		0.0	23.74	12.39	95.23	58.34	0.18	5.68
08.01.16	2		0.0	25.15	11.52	91.04	48.75	0.23	6.03
15.01.16	3		0.0	26.23	11.31	93.57	56.08	0.00	7.13
22.01.16	4	Flowering	0.4	26.86	12.14	93.71	47.16	0.00	7.85
29.01.16	5		0.6	27.41	13.96	92.37	60.26	0.28	8.05
05.02.16	6	Pod formation	1.1	27.92	9.32	93.25	50.18	0.23	6.74
12.02.16	7		1.5	28.13	14.95	92.06	49.72	0.10	7.58
19.02.16	8	Pod maturity	2.3	31.43	16.67	92.41	60.27	0.25	7.84
26.02.16	9		1.8	31.58	16.82	95.72	56.51	0.25	6.58
05.03.16	10		0.2	30.61	15.29	90.15	45.62	0.21	7.35

Table 2: Population dynamics of *H. armigera* (Hub.) on field pea during 2016-17

Date of observation	SMW	Crop stage	No. of pod borer larvae/ plant	Temperature (°C)		RH (%)		Wind speed (Km/h)	Bright Sunshine Hour (h)
				Max.	Min.	Max.	Min.		
24.12.16	52	Vegetative	0.0	25.87	12.93	95.86	65.29	0.00	5.59
01.01.17	1		0.0	25.67	12.41	94.86	57.14	0.00	6.21
08.01.17	2		0.0	24.13	10.59	91.00	47.29	0.00	7.62
15.01.17	3		0.0	26.29	8.80	90.00	43.29	0.00	7.91
22.01.17	4	Flowering	0.2	27.66	11.81	91.14	50.43	0.00	6.16
29.01.17	5		0.8	26.90	11.79	91.71	53.00	0.00	5.94
05.02.17	6	Pod formation	1.6	29.56	13.43	89.57	41.43	0.00	5.46
12.02.17	7		2.8	30.49	15.76	89.86	44.43	0.00	7.85
19.02.17	8	Pod maturity	4.2	31.86	18.59	88.57	44.29	0.09	6.48
26.02.17	9		3.2	33.27	16.50	91.29	47.00	0.03	7.88
05.03.17	10		0.6	31.43	19.29	95.14	60.86	0.09	8.13

Table 3: Population dynamics of *H. armigera* (Hub.) on field pea during 2017-18

Date of observation	SMW	Crop stage	No. of pod borer larvae/ plant	Temperature (°C)		RH (%)		Wind speed (Km/h)	Bright Sunshine Hour (h)
				Max.	Min.	Max.	Min.		
24.12.17	52	Vegetative	0.0	26.04	11.57	95.14	53.71	0.33	8.04
01.01.18	1		0.0	23.19	7.64	93.29	51.86	0.34	6.90
08.01.18	2		0.2	24.02	8.21	90.57	53.86	0.30	4.23
15.01.18	3		1.0	24.97	8.54	91.29	46.43	0.19	7.09
22.01.18	4	Flowering	3.2	27.40	9.76	89.14	42.14	0.37	7.84
29.01.18	5		6.6	32.29	11.29	90.71	45.43	0.26	8.03
05.02.18	6	Pod formation	4.8	31.39	12.66	89.00	43.71	0.19	6.80
12.02.18	7		2.4	32.41	13.96	88.14	43.43	0.43	7.40
19.02.18	8	Pod maturity	1.4	33.39	15.71	91.29	44.43	0.24	8.70
26.02.18	9		0.6	31.77	12.90	91.43	34.57	0.27	6.31
05.03.18	10		0.2	30.36	11.17	84.43	29.86	0.69	5.99

Table 4: Population dynamics of *H. armigera* (Hub.) on field pea during 2018-19

Date of observation	SMW	Crop stage	No. of pod borer larvae/ plant	Temperature (°C)		RH (%)		Wind speed (Km/h)	Bright Sunshine Hour (h)
				Max.	Min.	Max.	Min.		
19.12.18	51	Vegetative	0.0	24.27	14.47	89.00	56.86	0.36	3.63
26.12.18	52		0.0	23.23	10.79	95.86	52.29	0.24	7.07
02.01.19	1		0.0	23.04	7.69	92.86	40.29	0.30	7.91
09.01.19	2		0.0	25.06	8.93	90.86	41.43	0.21	7.47
16.01.19	3	Flowering	1.8	24.51	10.04	91.57	43.57	0.17	5.96
23.01.19	4		2.2	25.39	9.22	88.57	43.00	0.17	7.31
30.01.19	5	Pod formation	3.4	26.36	11.87	88.29	45.14	0.20	5.24
06.02.19	6		5.8	26.90	13.06	89.00	35.43	0.31	8.77
13.02.19	7	Pod maturity	6.4	27.19	12.90	91.00	40.29	0.33	6.69
20.02.19	8		3.0	28.87	13.69	89.29	40.71	0.31	7.99
27.02.19	9		2.1	28.74	15.32	92.21	41.42	0.31	6.87

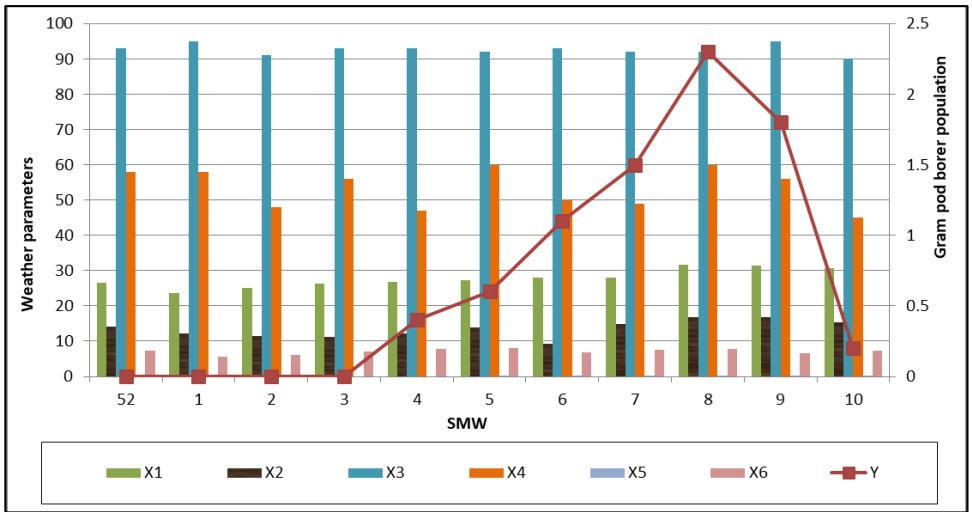

Fig 1: Seasonal incidence of gram pod borer during 2015-16

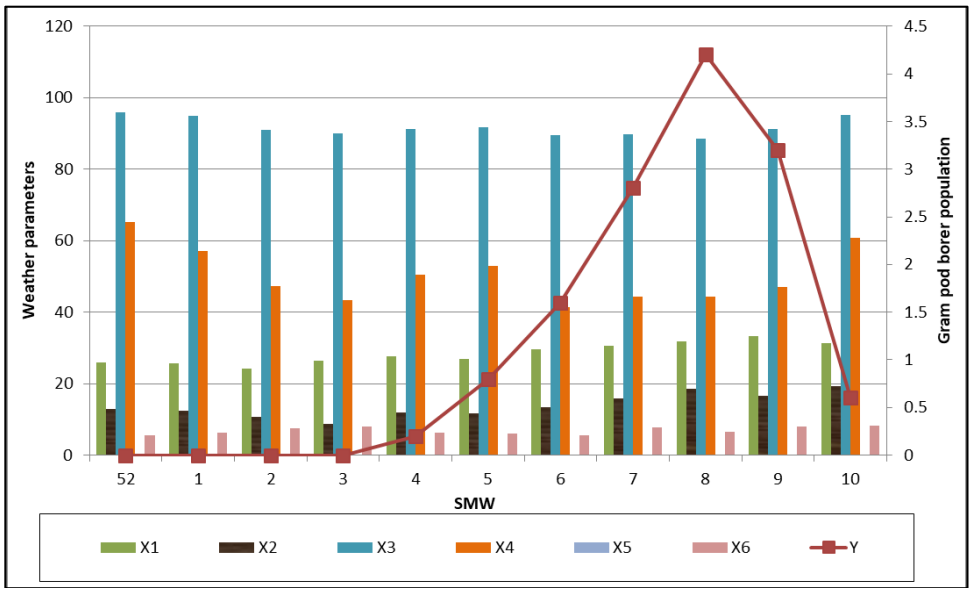

Fig 2: Seasonal incidence of gram pod borer during 2016-17

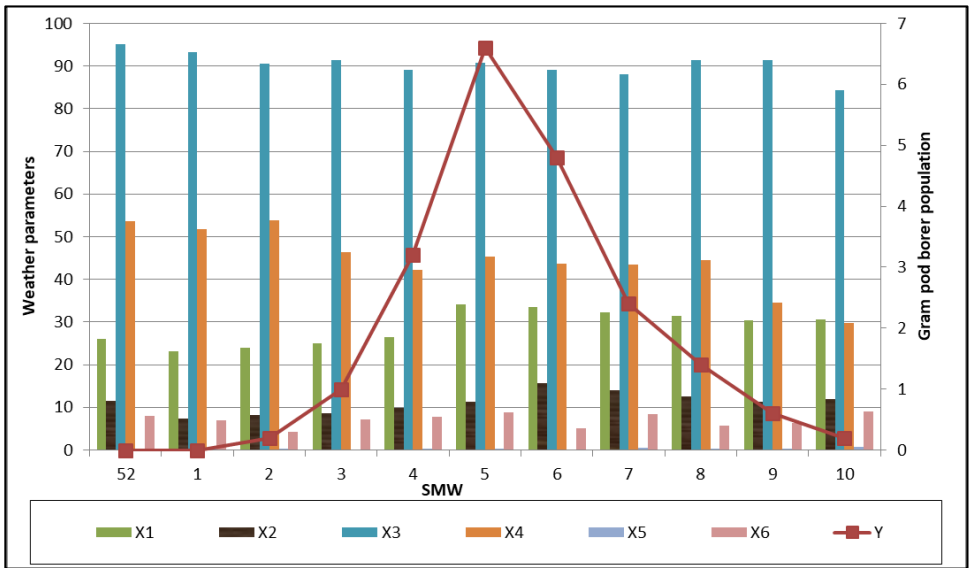

Fig 3: Seasonal incidence of gram pod borer during 2017-18

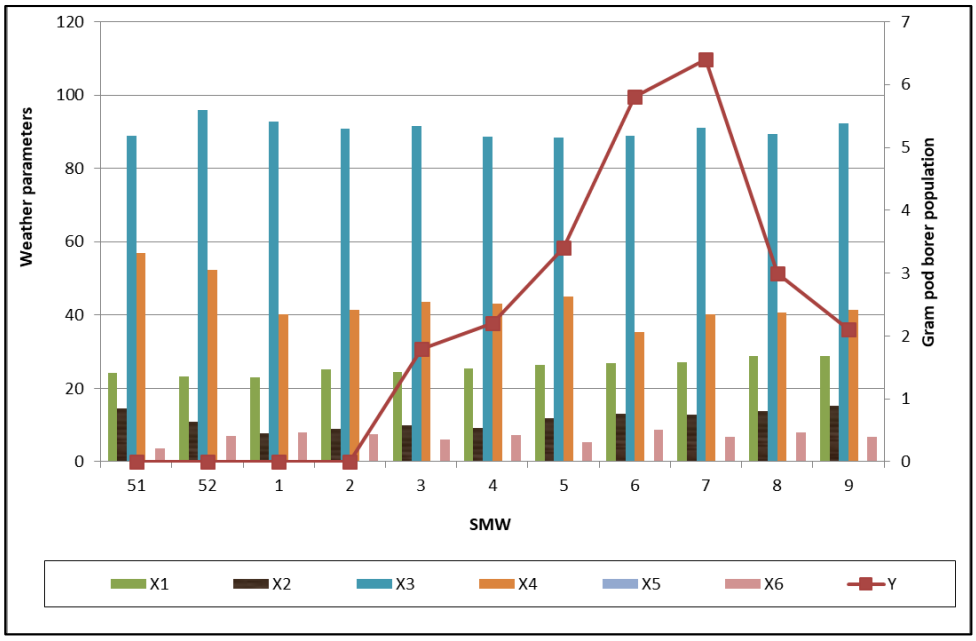

Fig 4: Seasonal incidence of gram pod borer during 2018-19

Impact of abiotic factors on the intensity of gram pod borer population

The correlation between gram pod borer population and different abiotic factors was presented in Table 5. The correlation studies revealed that the borer population exhibited highly significant positive association with maximum temperature in all the years of experimentation and correlation co-efficient (r) values were 0.762, 0.823, 0.671 and 0.650 during 2015-16, 2016-17, 2017-18 and 2018-19, respectively. Minimum temperature also showed positive correlation with intensity of gram pod borer but it was significant during first two seasons (r = 0.552 during 2015-16 and r = 0.691 during 2016-17) and non-significant in last two years (r = 0.448 during 2017-18 and r = 0.404 during 2018-19). Maximum and minimum relative humidity (RH) showed non-significant positive correlation (r = 0.118 and r = 0.204 respectively) with larval population during 2015-16. However, in rest of the years the larval population of *H. armigera* was negatively correlated with maximum and minimum RH. The correlation co-efficient values were -0.573 and -0.501 in 2016-17, -0.205 and -0.078 in 2017-18 and -0.422 and -0.581 in 2018-19. Wind speed did not show its impact in a set pattern on the population dynamics of gram pod borer. It showed non-significant positive relation with pest population during 2015-16 (r = 0.295), 2017-18 (r = 0.496) and 2018-19 (r = 0.203) but non-significant negative relation in 2016-17 (r = -0.312). The impact of bright sunshine hours on intensity of gram pod borer was not very much prominent, as the correlation coefficient values ranged from 0.150 to 0.314 in different years.

The results are in close conformity with Pandey *et al*. (2012) [8] who reported that the population of gram pod borer had significantly positive correlation with minimum and maximum temperature. Vaishampayan and Veda (1980) [20] reported that minimum temperature of 10-14°C was most favorable for larval development of gram pod borer. According to Sarder *et al*. (2018) [14], the temperature showed positive correction with larval population whereas relative humidity showed negative correlation with the larval population of gram pod borer which is in support with present study. The present findings are also in accordance with Pal *et al*. (2018) [7] who found significant positive relation of pod borer population with temperature and negative association with relative humidity. However, according to Singh *et al*. (2016) [17], relative humidity showed non-significant positive correlation with intensity of gram pod borer in chick pea. The present findings are in accordance with Patel *et al*. (2020) [9] who observed that bright sunshine hours had non-significant and positive correlation with larval population. The present findings are also in agreement with the findings of Ramesh Babu *et al*. (2009) [11] who recorded that sunshine hours had positive correlation with pod borer. Rathore *et al*. (2017) [12] also supports the present findings, who reported that gram pod borer on pigeon pea had significant and positive correlation with mean temperature while negative and non-significant correlation with relative humidity.

Weather based multiple linear regression models were developed in respect of seasonal incidence of gram pod borer (Y) as a dependent variable and meteorological parameters ($X_1$to X_6) as independent variables and presented in Table 6. The regression equations revealed that the various abiotic factors have profound influence on seasonal incidence of *H. armigera* in field pea. The coefficient of determination values (R^2) ranged from 0.64 to 0.88. It indicated that 64-88% variability in *Helicoverpa armigera* population was accounted by different weather parameters during four years of experimentation. The finding are in close conformity with Bahadur *et al*. (2018) [3] who found all the weather parameters together were responsible for 93% to 94% variability on larval incidence of gram pod borer on chickpea in Varanasi.

Table 5: Correlation between abiotic factors and larval population of *H. armigera* (Hub.)

Year	Temperature (°C)		RH (%)		Wind speed (Km/h)	Bright Sunshine Hour (h)
	Max.	Min.	Max.	Min.		
2015-16	0.762**	0.552*	0.118	0.204	0.295	0.314
2016-17	0.823**	0.691*	-0.573*	-0.501	0.496	0.150
2017-18	0.671*	0.448	-0.205	-0.078	-0.312	0.162
2018-19	0.650*	0.404	-0.422	-0.581*	0.203	0.259

*significant at 5% level ** significant at 1% level

Table 6: Multiple linear regression equations and co-efficient of determination (R^2) of gram pod borer population in relation to abiotic factors

Year	Multiple Regression Equation	R^2 Value
2015-16	$Y= -19.92 + 0.31X_1 – 0.02 X_2 + 0.13 X_3 + 0.02 X_4 – 0.32 X_5 – 0.09 X_6$	0.67
2016-17	$Y= 34.07 + 0.10 X_1 + 0.36 X_2 – 0.45 X_3 + 0.04 X_4 – 12.31 X_5 – 0.07 X_6$	0.88
2017-18	$Y= 37.25 + 0.42 X_1 – 0.23 X_2 – 0.58 X_3 + 0.15 X_4 – 12.43 X_5 + 0.67 X_6$	0.83
2018-19	$Y= 40.10 – 0.46 X_1 + 0.79 X_2 – 0.18 X_3 – 0.36 X_4 – 6.08 X_5 – 0.16 X_6$	0.64

NB: Y= Gram pod borer population, X_1 = Maximum temperature, X_2 = Minimum temperature, X_3 = Maximum RH, X_4 = Minimum RH, X_5 = Wind speed, X_6 = Bright Sunshine Hour

Conclusion

From this study it can be concluded that the maximum and minimum temperatures are most influencing factors over seasonal incidence of gram pod borer in field pea. Various meteorological parameters acting in combination can either foster or suppress the seasonal appearance of the insect pests. In any locality insect species lying in different parts of the year well adopted to the condition normally prevailing in that part of the year. The variation in the population dynamics of pod borer may be due to the crop phenology and fluctuations in the weather parameters. It has also been found that pest-weather regression models had significant contribution to understand the population dynamics of pod borer. This study may be helpful to challenge the pest by manipulating some cultural practices like adjustment of crop planting or harvesting time, timely application of pesticides etc. Based on the result of present investigation it can be advised that the spraying of insecticides during last week of January may be helpful to reduce the gram pod borer attack on field pea. Ultimately the knowledge on the seasonal incidence of gram pod borer will be helpful to develop an integrated pest management (IPM) module.

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