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Population Dynamics and Forewarning Models for Prediction of Population of *Helicoverpa armigera* under Different Sowing Window and Pigeonpea Varieties

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ABSTRACT

The correlation was carried out between weather parameter and population of *Helicoverpa armigera* on different pigeonpea varieties at different sowing windows and forewarning models for prediction of population of *H. armigera*, during 2017-18 and 2018-19. An experiment was laid out in split plot design with three replications. The treatment comprised of four varieties viz.,V_1: Vipula, V_2: Rajeshwari (Phule T 0012), V_3: BDN 711 and V_4: ICPH 2740 (*Mannem konda kandi)* as main plot and four sowing windows viz., D_1: 24th MW (11th to 17th June), D_2: 26th MW (25th June to 01st July), D_3: 28th MW (9th to 15th July) and D_4: 30th MW (23rd to 29th July) as sub-plot treatments.The population of *Helicoverpa armigera* larvae was increased gradually from 39th MW to 48th MW. The highest populations of larvae were 15.69 and 13.84 per five plants recorded, during 2017-18 and 2018-19, respectively, observed in var BDN 711. Sowing of pigeonpea during 30th MW (D_4) and 24th (D_1) recorded lower incidence of *H. armigera*, whereas, crop sown during 26th MW (D_2) recorded with maximum incidence. Among the pigeonpea varieties, higher incidence was recorded with BDN 711 and minimum was recorded on Rajeshwari followed by Vipula and Rajeshwari.The overall correlation of weather parameters with seasonal incidence of *H. armigera* found to have positively correlation with morning relative humidity and bright sunshine hrs whereas, maximum temperature, minimum temperature and rainfall showed negative. During second sowing window 26th MW (D_2) with var BDN 711 the population of population of *H. armigera* larvae per five plants for one week prior (W-1) was positively correlated with bright sunshine hrs (0.151 and 0.189), whereas, it was negative correlated with minimum temperature (-0.287 and -0.168), evening relative humidity (-0.241 and -0.288) and rainfall (-0.259 and -0.368) during *kharif* seasons of 2017-18 and 2018-19, respectively.Prediction of *H. armigera* larvae populations one week prior (W-1) in different sowing windows based on regression equations recorded (R^2) 53.6 to 87.4% validation for var Vipula, (R^2) 61.3 to 85.7 % validation for var Rajeshwari, (R^2) 58.4 to 76.4% validation for var BDN 711 and (R^2) 68.8 to 81.4% validation for var ICPH 2740. The overall linear multiple regression analysis was worked out

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between population of *H. armigera* on pigeonpea of W0 week with weather parameters of one week prior (W-1) for var BDN 711 and D_2 sowing window (26th MW). The forewarning model is (number of larvae) Y= –13.017 +5.671 (T_{max}) – 3.193 (T_{min}) – 0.783 (RH I) – 0.027(RH II) – 0.061 (Rainfall) –3.129 (BSS). An increase of one unit of maximum temperature increased the population of H. armigera by 5.671 units to an extent of 64.8 % (R2=0.648).

Keywords Correlation, Forewarning models, Sowing windows, Varieties, *Helicoverpa armigera.*

INTRODUCTION

Pigeonpea (*Cajanus cajan* (L.) Millspaugh) is one of the major pulse crops of the tropics and sub-tropics. It is the second most important pulse crop of India, after chickpea (Nene *et a*l.1990). Pigeonpea is grown on an area of 4.43 m ha and production of 4.25 m tonnes the productivity is 960 kg ha^{-1} in India (Anonymous 2019). Pigeonpea is grown throughout the country, except the hilly regions where winter temperature is very low. In India, Maharashtra, Andhra Pradesh and Gujarat account for a major pigeonpea growing states.

The production and productivity of this crop has remained stagnant over the past three decades due to its vulnerability to biotic and abiotic stresses.A large number of insect pests (more than 300 species) attack pigeonpea (Prasad and Singh 2004). Insects that attack the reproductive structures of plant cause the maximum yield losses (Rangaiah and Sehgal 1984). The most important pests those attack at flowering and podding stage of the crop are pigeonpea pod borer, *Helicoverpa armigera* (Hubner), spotted pod borer, *Maruca vitrata* (Fabricius), blue butterflies, *Lampides boeticus* L. and *Catochrysops strabo* (Fabricius), plume moth, *Exelastis atomosa* (Walsingham) and pod fly, *Melanagromyza obtusa* Malloch (Reed *et al.* 1989). Pod borers caused 60 to 90 % loss in the grain yield under favorable conditions, damage of seed by pod fly ranged from 14.3 to 46.6 % (Lal *et al.*1992) and loss of yield was recorded 60 to 80% due to the pod fly (Durairaj 2006). In all above *H.armigera,* the most devastating crop pest has become more abundant as a result of early rise in temperatures in North India, resulted in rapid generation turnover, lesser activity of natural enemies and lower efficacy of control measures.

Different strategies have to be involved for keeping the pest in check and stabilizing the productivity of the cropping system. The sowing window is one of the crop habitat desertification that is to be looked into, to minimize the incidence of insect pests on pigeonpea crop so that its yield can be enhanced. The sowing window takes the advantage of the absence of the pest or avoids susceptible stage of the crop. It prevents carryover of pests from early sown crop to late sown crop and prevents buildup of damaging populations. The pest forewarning model was able to predict the percent population of pod borer for different pigeonpea varieties and sowing windows with good r^2 values.

Keeping these facts in view, the correlation between weather parameter and population of pod borer (*H. armigera*) larvae per five plants on different pigeonpea varieties at different sowing windows and development of forewarning models for prediction of population pod borer (*H. armigera*) larvae per five plants was studied during, 2017-18 and 2018-19.

MATERIALS AND METHODS

An experiment was laid out in split plot design with three replications and sixteen treatment combinations formed considering different varieties and sowing windows. The gross and net plot size was 4.0 × 4.5 m^2 and 3.6 × 4.0 m^2, respectively for two consecutive years at Department of Agricultural Meteorology farm, College of Agriculture, Pune during 2017-18 and 2018-19.The geographical location of the site (Pune) was 18° 32'N, latitude; 73°51E, longitude and 559 m above mean sea level (MSL). The soil is medium black having depth of about 1m. Pune is situated in the sub-tropical region (Plain zone). The average annual rainfall of Pune is 675 mm, which is distributed from second fortnight of June to second fortnight of October. Out of total rainfall, about 75% is received from June to September during south-west monsoon, while remaining is received from north-east monsoon (October and November). The maximum temperature during the month of April and May is ranged between 34^{0}C to 40^{0}C. But on the onset of monsoon, it drops down to 27^{0}C. In the month of July and August, it is ranged from 26 to 30^{0}C. The minimum temperature varied from 6 to 10^{0}C in winter season from November to middle of February. Humidity of monsoon period i.e. from June to September is quite high during morning (about 85 to 93 %). The evening humidity is generally ranged between 43 to 83%. Urea and DAP were used as source of N and P and applied as per recommended dose i.e., 25 kg N and 50 kg. Seeds were treated with Thiram @ 4 g per kg of seed followed by *Rhizobium* and PSB @ 10 g per kg of seed.

Number of heliothis pod borer larvae

The observation on the incidence of Heliothis pod borer was recorded at weekly interval from five randomly selected and tagged plants from net plot. The effect of weather parameters viz., maximum and minimum temperatures (^{0}C), relative humidity (%) (morning and evening), bright sunshine hours, rainfall (mm) and rainy days, wind speed, evaporation rate on Heliothis pod borers were recorded from meteorological weeks 24th to 2nd during 2017-18 and 2018-19. The correlation studies were carried out between pest population, various above weather parameters of different sowing windows and varieties during 2017-18 and 2018-19. The multiple regression analysis was also worked out between Heliothis pod borer pest population and weather parameters.

The influence of weather parameters on pest population was estimated by using prediction equation as:

$$Y = a + b1x1+b2x2+b3x3+.......+ bnxn.$$

Where, Y= Pest population, ‘a’ as constant and ‘b’ as regression coefficients of independent variable ‘x’;

and also to study the influence of weather parameters on crop growth yield and yield attributes, initially simple correlations (Snedecor and Cochron 1968) were carried out.The forewarning models for different sowing windows and varieties of pigeonpea were worked out by statistical analysis using SPSS8.0 software with multiple linear regression method. The correlation coefficient values were further used for results and discussion.

RESULTS AND DISCUSSION

During the course of study the incidence of *H. armigera* was recorded on different pigeonpea varieties were sown at different sowing windows. The incidence of *H. armigera* was recorded on all varieties during the year 2017-18 and 2018-19 and presented

Table 1. Mean number of pod borer (*H. armigera*) larvae on varVipula as influenced by different sowing windows.

	Number of heliothis larvae per five plants							
	2017-18				2018-19			
SWM	D_1 (24th MW)	D_2 (26th MW)	D_3 (28th MW)	D_4 (30th MW)	D_1 (24th MW)	D_2 (26th MW)	D_3 (28th MW)	D_4 (30th MW)
39	0.23	0.54	0	0	0.21	0.16	0	0
40	0.67	1.32	1.13	0.25	0.56	0.94	0.63	0.32
41	2.64	2.01	2.05	0.65	0.84	1.74	1.54	0.83
42	4.25	3.54	3.68	0.98	1.64	2.55	2.09	1.08
43	6.25	5.83	5.27	1.57	3.87	4.68	2.38	1.94
44	7.31	6.58	6.85	2.98	5.89	7.58	3.87	2.34
45	9.68	8.66	8.62	3.67	8.64	8.38	7.68	3.55
46	11.54	10.37	10.63	5.34	10.58	10.67	8.85	4.38
47	8.34	12.21	11.97	8.64	8.35	12.37	9.37	6.57
48	5.21	9.35	8.34	10.85	6.52	10.64	10.64	7.64
49	2.84	5.34	4.38	9.67	3.64	7.64	9.64	9.54
50	0.74	2.74	3.67	6.58	0.57	2.66	5.64	8.34
51	0	0.34	1.28	3.66	0	0.54	2.17	3.64
52	-	0	0	0	-	0	0	0
Mean	4.59	4.92	4.85	3.92	3.95	5.04	4.61	3.58

Table 2. Mean number of pod borer (*H. armigera*) larvae on var Rajeshwari as influenced by different sowing windows.

SWM	Number of Heliothis larvae per five plants 2017-18 D_1 (24th MW)	D_2 (26th MW)	D_3 (28th MW)	D_4 (30th MW)	2018-19 D_1 (24th MW)	D_2 (26th MW)	D_3 (28th MW)	D_4 (30th MW)
38	0.52	0.53	0.00	0.00	0.44	0.00	0.00	0.00
39	1.32	1.81	0.66	0.00	0.87	0.24	0.32	0.00
40	2.69	3.18	1.31	0.84	1.82	0.91	0.62	0.19
41	4.34	3.82	2.03	1.47	2.87	2.04	1.94	0.62
42	4.66	4.53	2.68	2.19	3.25	2.64	2.38	1.44
43	5.23	5.42	3.67	2.65	4.09	3.42	2.67	1.72
44	6.68	6.32	4.81	3.69	5.27	4.08	3.97	2.49
45	5.67	7.77	5.87	4.84	5.77	5.61	4.67	3.29
46	3.19	6.80	7.43	5.76	4.74	6.93	5.29	4.03
47	2.66	5.37	6.18	4.47	3.42	5.14	6.27	5.44
48	1.03	3.68	4.69	3.29	1.88	3.42	4.79	4.29
49	0.17	2.18	3.27	2.16	0.54	1.93	2.59	2.82
50	0	0.61	1.53	0.84	0	0.62	1.17	1.53
51	-	0	0	0	-	0	0	0
Mean	2.93	3.71	3.15	2.30	2.69	2.64	2.62	1.99

in Tables 1 - 4 and graphically depicted, in Figs. 1-4, across all sowing windows.

The larvae feed for a short time on the tender leaflets by scrapping green tissue and then shift to flower buds and tender shoots. Slowly it enters and feeds on the seeds inside the pods. The half portion of larvae remains inside pod while feeding on the developing seeds. They can cut hole on one to another locule and feed 20-25 pods in its lifetime.

Population dynamics of *H. armigera* larvae per five plants on different pigeonpea varieties under sowing window (D_1) 24th MW

During the year 2017-18, first sowing window 24th MW (D_1) with the varieties Vipula (V_1), Rajeshwari (V_2) and BDN 711 (V_3) and ICPH 2740 (V_4) recorded

Table 3. Mean number of pod borer (*H. armigera*) larvae on var BDN 711 as influenced by different sowing windows.

SWM	Number of heliothis larvae per five plants 2017-18 D_1 (24th MW)	D_2 (26th MW)	D_3 (28th MW)	D_4 (30th MW)	2018-19 D_1 (24th MW)	D_2 (26th MW)	D_3 (28th MW)	D_4 (30th MW)
39	0.84	0.86	0	0	0.89	0.34	0	0
40	1.68	1.49	0.58	0	1.37	0.76	0.52	0
41	2.76	2.87	1.61	0	3.08	1.85	0.96	0.76
42	4.95	4.67	2.84	0.76	5.76	3.57	1.38	0.98
43	6.08	7.82	3.58	1.84	6.98	6.08	3.07	1.57
44	8.67	9.84	5.75	3.29	9.07	7.94	5.16	3.84
45	11.5	12.54	6.17	5.86	10.66	10.38	8.37	5.76
46	13.37	13.67	9.94	6.28	11.94	12.09	10.33	8.09
47	10.87	15.69	11.73	7.84	9.57	13.84	12.67	9.58
48	7.48	11.64	14.52	9.85	6.24	10.59	9.84	10.82
49	4.67	8.64	11.98	11.65	3.56	8.34	6.76	8.67
50	1.96	4.78	8.37	8.94	0.94	4.49	4.55	5.84
51	0	2.34	3.84	2.54	0	2.08	2.69	2.67
52	-	0	0	0	-	0	0	0
Mean	5.76	6.92	5.78	4.20	5.39	5.88	4.74	4.18

Table 4. Mean number of pod borer (*H. armigera*) larvae on var ICPH 2740 as influenced by different sowing windows.

SWM	Number of heliothis larvae per five plants 2017-18				2018-19			
	D_1 (24[th] MW)	D_2 (26[th] MW)	D_3 (28[th] MW)	D_4 (30[th] MW)	D_1 (24[th] MW)	D_2 (26[th] MW)	D_3 (28[th] MW)	D_4 (30[th] MW)
40	0.28	0.16	0	0	0.34	0.66	0	0
41	0.94	0.84	0.78	0.43	0.67	0.85	0.31	0.27
42	2.31	1.36	1.12	0.82	1.94	1.98	0.93	0.86
43	3.84	2.64	2.04	1.27	3.89	3.03	1.66	1.08
44	4.87	4.27	3.84	3.58	5.33	5.47	3.06	2.84
45	6.49	5.59	6.07	4.21	6.84	6.59	4.38	3.22
46	9.84	7.09	6.84	5.08	7.15	7.84	6.28	4.96
47	10.34	9.78	8.94	6.94	8.99	9.44	7.57	6.35
48	11.34	10.84	9.48	8.04	9.84	10.58	9.14	7.06
49	8.94	12.34	11.58	9.68	8.67	11.63	10.11	8.22
50	5.94	10.08	10.57	11.67	5.43	9.58	10.85	8.76
51	3.64	8.61	9.57	10.57	3.54	6.37	7.58	6.84
52	1.94	5.37	7.89	6.94	1.94	3.08	4.67	5.49
1	0	2.94	4.28	3.51	0	1.54	2.46	2.68
2	-	0	0	0	-	0	0	0
Mean	4.71	5.46	5.53	4.85	4.30	5.24	4.60	3.91

the mean incidence of 4.59, 2.93, 5.76 and 4.71 larvae per five plants and which were at peak with 11.54, 6.67, 13.37 and 11.34 larvae per five plants. During the year 2018-19, the first sowing window 24[th] MW (D_1) with the varieties Vipula (V_1), Rajeshwari (V_2) and BDN 711 (V_3) and ICPH 2740 (V_4) recorded the mean incidence was 3.95, 2.69, 5.39 and 4.30 larvae per five plants which were at peak with 10.58, 5.77, 11.94 and 9.84 larvae per five plants, resulted the peak population of larvae was noticed at 46[th] MW with sowing window 24[th] MW, during both the year 2017-18 and 2018-19. These results are in conformity with the findings of Bengai *et al*. (2004), Singh *et al.* (2010), (Bedis *et al.* 2014), Rathore *et al.* (2017).

Population dynamics of *H. armigera* larvae per five plants on different pigeonpea varieties under sowing window (D_2) 26[th] MW

During the year 2017-18, second sowing window 26[th] MW (D_2) with the varieties Vipula (V_1), Rajeshwari

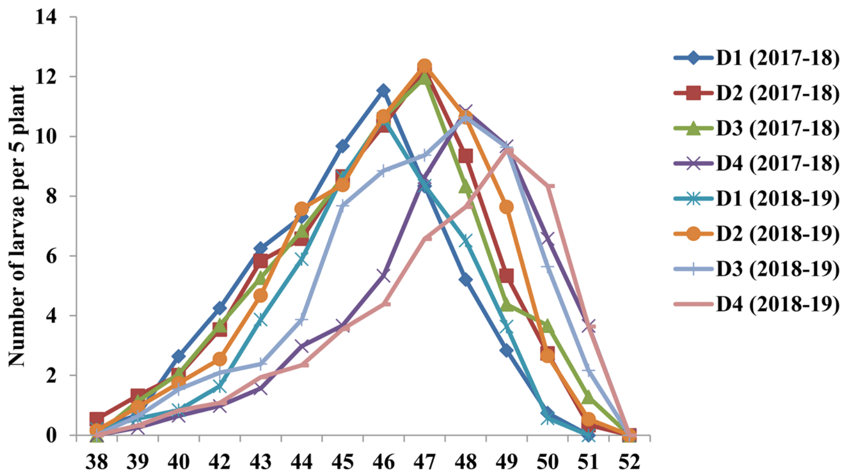

Fig. 1. Mean number of pod borer (*H. armigera*) larvae on var Vipula (V_1) as influenced by different sowing windows.

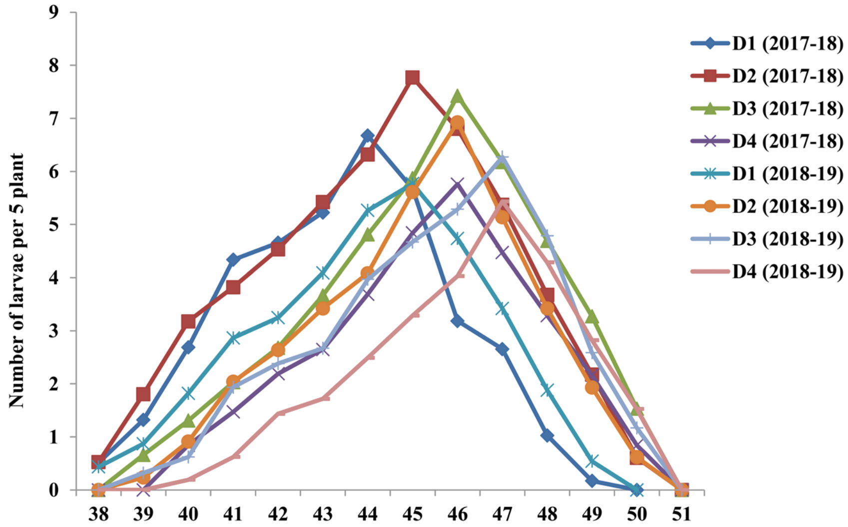

Fig. 2. Mean number of pod borer (*H. armigera*) larvae on var Rajeshwari (V_2) as influenced by different sowing windows.

(V_2) and BDN 711 (V_3) and ICPH 2740 (V_4) recorded the mean incidence of 4.59, 3.71, 6.92 and 5.46 larvae per five plants and which were at peak with 12.21, 7.77, 15.69 and 12.34 larvae per five plants. During the year 2018-19, the second sowing window 26th MW (D_2) with the varieties Vipula (V_1), Rajeshwari (V_2) and BDN 711 (V_3) and ICPH 2740 (V_4) recorded the mean incidence was 5.04, 2.64, 5.88 and 5.24 larvae per five plants and which were at peak with 12.37, 6.93, 13.84 and 11.63 larvae per five plants, resulting the peak population of larvae was noticed at 47th MW with sowing window 26th MW, during both the years 2017-18 and 2018-19. These results are in conformity with the results of Bengai *et al.* (2004), Singh *et al.* (2010), Yadav *et al.* (2011), (Bedis *et al.* 2014), Rathore *et al.* (2017).

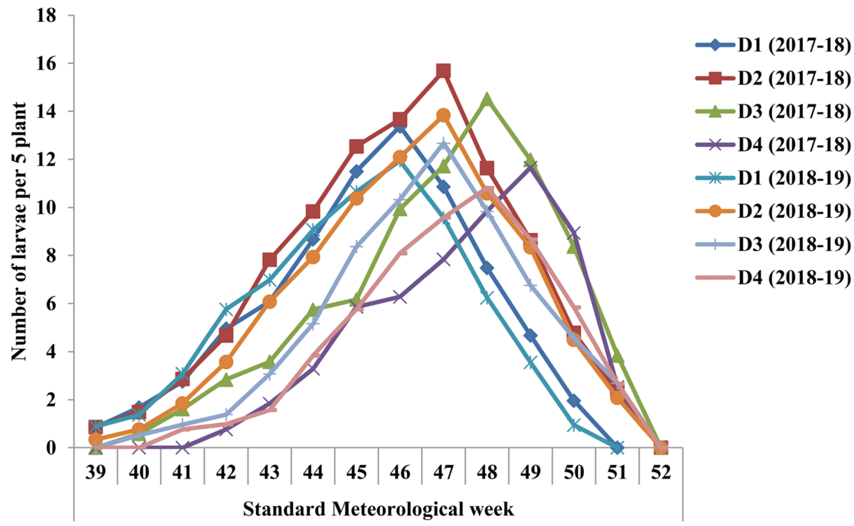

Fig. 3. Mean number of pod borer (*H. armigera*)) larvae on var BDN 711 (V_3) as influenced by different sowing windows.

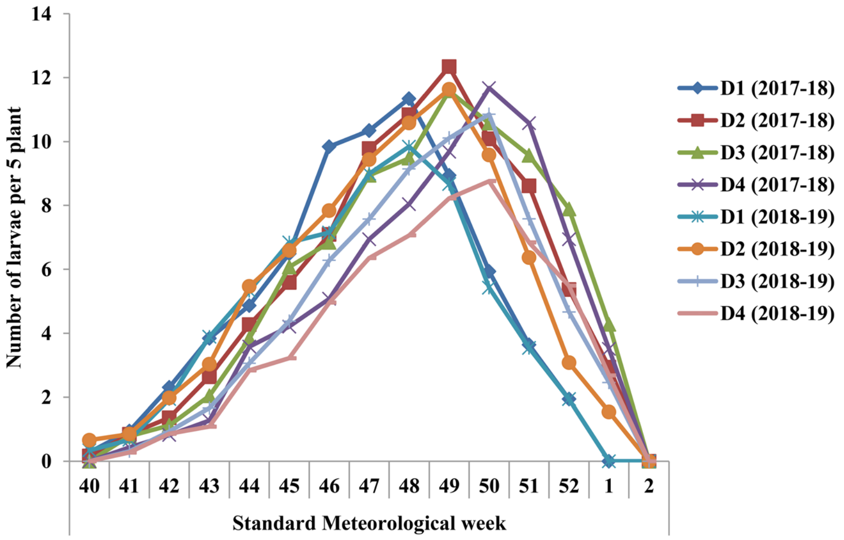

Fig. 4. Mean number of pod borer (*H. armigera*) larvae on var ICPH 2740 (V_4) as influenced by different sowing windows.

Population dynamics of *H. armigera* larvae per five plants on different pigeonpea varieties under sowing window (D_3) 28th MW

During the year 2017-18, second sowing window 28th MW (D_3) with the varieties Vipula (V_1), Rajeshwari (V_2) and BDN 711 (V_3) and ICPH 2740 (V_4) recorded the mean incidence of 4.85, 3.15, 5.78 and 5.53 larvae per five plants and which were at peak with 11.97, 7.43, 14.52 and 11.58 larvae per five plants. During the year 2018-19, the first sowing window 28th MW (D_3) with the varieties Vipula (V_1), Rajeshwari (V_2) and BDN 711 (V_3) and ICPH 2740 (V_4) recorded the mean incidence was 4.61, 2.62, 4.74 and 4.60 larvae per five plants and which were at peak with 10.64, 6.27, 13.84 and 10.85 larvae per five plants, resulting the peak population of larvae was noticed at 48th and 47th MW with sowing window 28th MW, during both the years 2017-18 and 2018-19 respectively. These results are in conformity with the results of Bengai *et al.* (2004), Singh *et al*. (2010), Yadav *et al.* (2011), (Bedis *et al*. 2014), Rathore *et al*. (2017).

Population dynamics of *H. armigera* larvae per five plants on different pigeonpea varieties under sowing window (D_4) 30th MW

During the year 2017-18, second sowing window 30th MW (D_4) with the varieties Vipula (V_1), Rajeshwari (V_2) and BDN 711 (V_3) and ICPH 2740 (V_4) recorded the mean incidence of 3.92, 2.30, 4.20 and 4.85 larvae per five plants and which were at peak with 10.85, 5.76, 11.65 and 11.67 larvae per five plants. During the year 2018-19, the first sowing window 30th MW (D_4) with the varieties Vipula (V_1), Rajeshwari (V_2) and BDN 711 (V_3) and ICPH 2740 (V_4) recorded the mean incidence was 3.58, 1.99, 4.18 and 3.91 larvae per five plants and which were at peak with 9.54, 5.44, 10.82 and 8.76 larvae per five plants, resulted the peak population of larvae was noticed at 49th and 48th MW with sowing window 30th MW, during both the years 2017-18 and 2017-18 and 2018-19, respectively.

First sowing and last sowing windows of weather parameters are not much favourable for increasing the population of pod borer. Dodia (1992) from Gujarat reported early sown (1st week of June) pigeonpea was less damaged by pigeonpea pod borer, *H. armigera* than late sown (1st week of July and 1st week of August). These results are in accodance with the results of Bengai *et al.* (2004), Singh *et al.* (2010), Yadav *et al.* (2011), (Bedis *et al*. 2014), Rathore *et al.* (2017), Waghmare (2019).

Correlation between weather parameters and population of pod borer (*H. armigera*) larvae on different pigeonpea varieties at different sowing windows and forewarning models for incidence of pod borer, *H. armigera*

The influence of different weather parameters viz., maximum and minimum temperature, morning and evening relative humidity, wind speed evaporation and rainfall on the seasonal population of *H. armigera* larva per five plants was observed by working out correlation coefficient (r) (Tables 5 and 6) and forewarning models were developed are given in Tables 4-7.

Results of the cumulative correlation showed that the population of pod borer was found to have significant and negative correlation with maximum and minimum temperature and wind speed is significant and positive correlation. On the basis of different sowing windows and varieties, the incidence of *H. armigera* with weather factors was studies.

Correlation between weather parameter and population of pod borer (*H. armigera*) larvae on different pigeonpea var Vipula at different sowing windows and forewarning models for prediction of population of pod borer (*H. armigera*)

During first sowing window 24th MW (D_1) with varVipula, the population of *H. armigera* larvae per five plants for one week prior (W-1) was positively correlated with bright sunshine hours (0.325 and 0.404), whereas, it was negatively correlated with minimum temperature (-0.131 and -0.246), evening humidity (-0.493 and -0.429), wind speed (-0.003 and -0.305) and rainfall (-0.184 and -0.335) during *kharif* season 2017-18 and 2018-19, respectively.

The overall linear multiple regression analysis was worked out between population of *H.armigera* on pigeonpea of W0 week with weather parameters of one week prior (W-1) for varVipula and D_1 sowing window (24th MW). The results obtained are given as follows.

The multiple regression equation is given below:
$Y = -40.553 + 5.488\,(T_{max}) - 2.536\,(T_{min}) - 0.711\,(RH\ I) + 0.013\,(RH\ II) - 0.032\,(Rainfall) - 2.8\,(BSS)$.

An increase of one unit of maximum temperature increased the population of *H.armigera* by 5.488 units to an extent of 55.3 % (R^2=0.553).

During second sowing window 26th MW (D_2) with var Vipula, the population of *H. armigera* larvae per five plants for one week prior (W-1) was positive-

Table 5. Correlation between weather parameters and population of pod borer, *H. armigera* larvae per five plants during 2017-18. Where, T_{max}: Maximum temperature, RH-II: Evening relative humidity, WS: Wind speed, Epan: Pan evaporation * Significant at 0.05% level, T_{min}: Minimum temperature, RH-I: Morning relative humidity, RF: Rainfall, BSS: Bright sunshine hours ** Significant at 0.01%

Treatments		r' values							
Sowing window	Variety	T_{max}	T_{min}	RH-I	RH-II	Wind speed	Rainfall	Epan	BSS
D_1- 24th MW	V_1- Vipula	-0.131	-0.405	0.352	-0.493	-0.003	-0.184	-0.040	0.325
D_2- 26th MW	V_1- Vipula	-0.105	-0.246	0.271	-0.209	0.074	-0.227	-0.077	0.132
D_3- 28th MW	V_1- Vipula	-0.134	-0.312	0.291	-0.273	0.077	-0.243	-0.066	0.174
D_4- 30th MW	V_1- Vipula	-0.522	-0.402	0.210	-0.038	0.330	-0.345	-0.368	-0.021
D_1- 24th MW	V_2 - Rajeshwari	0.096	-0.191	0.367	-0.465	-0.093	-0.033	0.168	0.339
D_2- 26th MW	V_2 - Rajeshwari	-0.026	-0.133	0.276	-0.183	0.047	-0.085	-0.005	0.076
D_3- 28th MW	V_2 - Rajeshwari	-0.319	-0.368	0.280	-0.187	0.200	-0.298	-0.218	0.092
D_4- 30th MW	V_2 - Rajeshwari	-0.289	-0.359	0.277	-0.210	0.167	-0.283	-0.214	0.101
D_1- 24th MW	V_3 - BDN 711	-0.165	-0.438	0.357	-0.472	0.027	-0.251	-0.065	0.329
D_2- 26th MW	V_3 - BDN 711	-0.189	-0.287	0.241	-0.241	0.197	-0.259	-0.062	0.151
D_3- 28th MW	V_3 - BDN 711	-0.543*	-0.492	0.257	-0.162	0.299	-0.373	-0.343	0.052
D_4- 30th MW	V_3 - BDN 711	-0.714**	-0.583*	0.160	-0.205	0.535*	-0.468	-0.386	0.120
D_1- 24th MW	V_4 - ICPH 2740	-0.285	-0.277	0.030	-0.032	0.395	-0.326	-0.043	0.125
D_2- 26th MW	V_4 - ICPH 2740	-0.465	-0.378	-0.059	-0.106	0.535*	-0.353	-0.194	0.087
D_3- 28th MW	V_4 - ICPH 2740	-0.586*	-0.521*	-0.005	-0.203	0.537*	-0.402	-0.262	0.165
D_4- 30th MW	V_4 - ICPH 2740	-0.575*	-0.526*	-0.020	-0.199	0.522*	-0.398	-0.216	0.179

Table 6. Correlation between weather parameters and population of pod borer, H. armigera larvae per five plants during 2018-19. Where, T_{max}: Maximum temperature, RH-II: Evening relative humidity, WS: Wind speed,Epan: Pan evaporation * Significant at 0.05% level, T_{min}: Minimum temperature, RH-I: Morning relative humidity, RF: Rainfall, BSS: Bright sunshine hours ** Significant at 0.01%.

Treatments		r' values							
Sowing window	Variety	T_{max}	T_{min}	RH-I	RH-II	Wind speed	Rainfall	Epan	BSS
D_1- 24th MW	V_1- Vipula	0.187	-0.246	0.107	-0.429	-0.305	-0.335	.0.240	0.404
D_2- 26th MW	V_1- Vipula	0.129	-0.146	-0.154	-0.267	-0.216	-0.342	0.235	0.157
D_3- 28th MW	V_1- Vipula	-0.104	-0.310	0.123	-0.191	-0.419	-0.377	-0.065	0.002
D_4- 30th MW	V_1- Vipula	-0.462	-0.512	0.189	-0.075	-0.374	-0.446	-0.418	-0.084
D_1- 24th MW	V_2 - Rajeshwari	0.398	-0.044	-0.238	-0.509	-0.192	-0.237	0.438	0.417
D_2- 26th MW	V_2 - Rajeshwari	0.106	-0.153	-0.163	-0.289	-0.217	-0.346	0.220	0.168
D_3- 28th MW	V_2 - Rajeshwari	-0.066	-0.305	0.074	-0.275	-0.386	-0.376	0.025	0.074
D_4- 30th MW	V_2 - Rajeshwari	-0.311	-0.485	0.183	-0.223	-0.398	-0.466	-0.200	0.056
D_1- 24th MW	V_3 - BDN 711	0.396	-0.049	-0.291	-0.512	-0.171	-0.249	0.444	0.467
D_2- 26th MW	V_3 - BDN 711	0.108	-0.168	-0.148	-0.288	-0.277	-0.368	0.203	0.189
D_3- 28th MW	V_3 - BDN 711	-0.075	-0.305	-0.016	-0.227	-0.320	-0.400	0.031	0.154
D_4- 30th MW	V_3 - BDN 711	-0.275	-0.458	0.134	-0.199	-0.366	-0.456	-0.188	0.067
D_1- 24th MW	V_4 - ICPH 2740	-0.118	-0.119	-0.104	0.027	-0.056	-0.431	0.104	0.040
D_2- 26th MW	V_4 - ICPH 2740	-0.310	-0.132	-0.084	0.196	0.045	-0.392	-0.031	-0.067
D_3- 28th MW	V_4 - ICPH 2740	-0.574*	-0.361	0.091	0.150	-0.053	-0.447	-0.302	-0.023
D^4- 30th MW	V4 - ICPH 2740	-0.679**	-0.460	0.113	0.127	-0.070	-0.480	-0.419	0.031

ly correlated with bright sunshine hours (0.132 and 0.157), whereas, it was negatively correlated with minimum temperature (-0.246 and -0.146), evening humidity (-0.209 and -0.267) and rainfall (-0.227 and -0.342) during *kharif* season 2017-18 and 2018-19, respectively.

The overall linear multiple regression analysis was worked out between population of *H.armigera* on pigeonpea of W0 week with weather parameters of one week prior (W-1) for varVipula and D_2 sowing window (26th MW). The results obtained are given as follows.

The multiple regression equation is given below:

$$Y = -42.541 + 6.141\,(T_{max}) - 3.085\,(T_{min}) - 0.742\,(RH\ I) + 0.112\,(RH\ II) - 0.079\,(Rainfall) - 4.062\,(BSS)$$

An increase of one unit of maximum temperature and evening relative humidity increased the population of *H. armigera* by 6.141 and 0.112 units. These weather parameters collectively increased the population of *H. armigera* to an extent of 76.2 % (R^2=0.762).

During third sowing window 28th MW (D_3) with varVipula the population of population of *H. armigera* larvae per five plants for one week prior (W-1) was positively correlated with morning relative humidity (0.291 and 0.123) and bright sunshine hrs (0.174 and 0.002), whereas, it was negatively correlated with maximum temperature (-0.134 and -0.104) minimum temperature (-0.312 and -0.310), evening relative humidity (-0.273 and -0.191), rainfall (-0.243 and -0.377) and evaporation (0.066 and -0.065) during *kharif* seasons of 2017-18 and 2018-19, respectively.

The overall linear multiple regression analysis was worked out between population of *H. armigera* on pigeonpea of W0 week with weather parameters of one week prior (W-1) for varVipula and D3 sowing window (28th MW). The results obtained are given as follows.

The multiple regression equation is given below:

$$Y = -49.385 + 5.462\,(T_{max}) - 2.893\,(T_{min}) - 0.500\,(RH\ I) + 0.140\,(RH\ II) - 0.076\,(Rainfall) - 3.868\,(BSS)$$

An increase of one unit of maximum temperature and evening relative humidity increased the population of *H. armigera* by 5.462 and 0.140 units, respectively. These weather parameters collectively increased the population of *H.armigera* to an extent of 87.4 % (R^2=0.874).

Table 7. Forewarning models for one week prior (W-1) for prediction of pod borer, *H. armigera* larvae on pigeonpea during 2017-18 and 2018-19.

Sowing window	Treatments Variety	Forewarning model	R^2 Value
D_1- 24th MW	Vipula	Y= – 40.553+ 5.488 (T_{ma}x) – 2.536 (T_{min}) – 0.711 (RH I) + 0.013 (RH II)– .032 (Rainfall) – 2.8 (BSS)	0.553
D_2- 26th MW	Vipula	Y= – 42.541+ 6.141 (T_{max}) – 3.085 ($_{Tmin}$) – 0.742 (RH I) + 0.112 (RH II) – 079 (Rainfall) – 4.062 (BSS)	0.762
D_3- 28th MW	Vipula	Y= – 49.385+ 5.462 (T_{max}) – 2.893 ($_{Tmin}$) – 0.500 (RH I) + 0.140 (RH II)– 0.076 (Rainfall) –3.868 (BSS)	0.874
D_4- 30th MW	Vipula	Y= –8.960 + 1.211 (T_{max}) – 1.078 (T_{min}) – 0.080 (RH I) + 0.117 (RH II) – 0.108 (Rainfall)– 2.477 (BSS)	0.536
D_1- 24th MW	Rajeshwari	Y= – 45.229+ 4.648 (T_{max}) –1.603 (T_{min}) – 0.454(RH I) – 0.213 (RH II)– 0.009 (Rainfall)– 2.416 (BSS)	0.613
D_2- 26th MW	Rajeshwari	Y= – 40.093+ 6.764 (T_{max}) – 3.264 ($T_{min)}$) – 0.848(RH I) + 0.025 (RH II) – 0.062 (Rainfall)– 4.638 (BSS)	0.775
D_3- 28th MW	Rajeshwari	Y= –49.356 + 5.557 (T_{max}) –2.943 (T_{min}) – 0.423(RH I) + 0.107 (RH II) – 0.113 (Rainfall)– 4.667 (BSS)	0.857
D_4- 30th MW	Rajeshwari	Y= – 32.726 +3.776 (T_{max}) – 2.135 (T_{min}) + 0.274(RH I)+ 0.109 (RH II)– 0.092 (Rainfall) 3.280 (BSS)	0.641
D_1- 24th MW	BDN 711	Y= – 28.347+ 5.628 (T_{max}) – 2.682 (T_{min}) – 0.772(RH I)– 0.102 (RH II) – 0.010 (Rainfall)– 3.111(BSS)	0.674
D_2- 26th MW	BDN 711	Y= –13.017 + 5.671 (T_{Tmax}) – 3.193 (T_{min}) – 0.783 (RH I) – 0.027 (RH II) – 0.061 (Rainfall) –3.129 (BSS)	0.584
D_3- 28th MW	BDN 711	Y= – 21.029 + 4.665 (T_{max}) – 3.172 (T_{min}) – 0.459 (RH I) +0.145 (RH II) – 0.068 (Rainfall) -4.051 (BSS)	0.736
D_4- 30th MW	BDN 711	Y= – 2.869 + 1.611 (T_{max}) – 1.650 (T_{min}) + 0.011 (RH I) + 0.088 (RH II) – 0.084 (Rainfall) – 2.586 (BSS)	0.764
D_1- 24th MW	ICPH 2740	Y= – 2.869 + 1.611 (T_{max}) – 1.650 (T_{min}) + 0.011 (RH I) + 0.088 (RH II)– 0.084 (Rainfall) – 2.586 (BSS)	0.814
D_2- 26th MW	ICPH 2740	Y= 66.728 – 2.065 (T_{max}) – 0.553 (T_{min}) – 0.163 (RH I) + 0.141 (RH II)– 0.121 (Rainfall) + 0.547 (BSS)	0.728
D_3- 28th MW	ICPH 2740	Y= 73.950 – 2.710 (T_{max}) – 0.642 (T_{min}) – 0.039 (RH I) + 0.103 (RH II)– 0.096 (Rainfall) + 0.689 (BSS)	0.771
D_4- 30th MW	ICPH 2740	Y= 76.411 – 2.929 (T_{max}) + 0.691 (T_{min}) – 0.039 (RH I) + 0.10 3 (RH II) – 0.072 (Rainfall) +1.048 (BSS)	0.688

During fourth sowing window 30th MW (D_4) with varVipula the population of *H. armigera* larvae per five plants for one week prior (W-1) was positively correlated with morning relative humidity (0.210 and 0.189), whereas, it was negatively correlated with maximum temperature (-0.522 and -0.462) minimum temperature (-0.402 and -0.412), evening relative humidity (-0.038 and -0.075), rainfall (-0.345 and -0.446), evaporation (0.368 and -0.418) and bright sunshine hours (-0.021 and -0.084) during *kharif* seasons of 2017-18 and 2018-19, respectively.

The overall linear multiple regression analysis was worked out between population of *H. armigera* on pigeonpea of W0 week with weather parameters of one week prior (W-1) for varVipula and D_4 sowing window (30th MW). The results obtained are given as follows.

The multiple regression equation is given below:

$$Y= -8.960 + 1.211 (T_{max}) – 1.078 (T_{min}) -0.080 (RH I) + 0.117 (RH II) – 0.108 (Rainfall) -2.477 (BSS)$$

An increase of one unit of maximum temperature and evening relative humidity increased the population of *H. armigera* by 1.211 and 0.117 units, respectively. These weather parameters collectively increased the population of *H. armigera* to an extent of 53.6 % (R^2=0.536).

Correlation between weather parameters and population of *H. armigera* larvae per five plants on pigeonpea var Rajeshwari at different sowing windows and forewarning models for prediction of incidence of *H. armigera*

During first sowing window 24th MW (D_1) with var-Rajeshwari the population of *H. armigera* larvae per five plants for one week prior (W-1) was positively correlated with maximum temperature (0.096 and 0.398), evaporation (0.168 and 0.438) and bright sunshine hrs (0.339 and 0.417), whereas, it was negatively correlated with minimum temperature (-0.191 and -0.044), evening relative humidity (-0.465 and -0.509), wind speed (-0.093 and -0.192) and rainfall (-0.033 and -0.237) during *kharif* seasons of 2017-18 and 2018-19, respectively.

The overall linear multiple regression analysis was worked out between population of *H. armigera* on pigeonpea of W0 week with weather parameters of one week prior (W-1) for var Rajeshwari and D_1 sowing window (24th MW). The results obtained are given as follows.

The multiple regression equation is given below:

$$Y= -45.229 + 4.648 (T_{max}) – 1.603 (T_{min}) – 0.454 (RH I) – 0.213 (RH II) – 0.009 (Rainfall) – 2.416 (BSS)$$

An increase of one unit of maximum temperature increased the population of *H. armigera* by 4.648 units to an extent of 61.3 % (R^2=0.613).

During second sowing window 26th MW (D^2) with var Rajeshawri the population of *H. armigera* larvae per five plants for one week prior (W-1) was positively correlated with bright sunshine hrs (0.339 and 0.168), whereas, it was negatively correlated with minimum temperature (-0.133 and -0.153), evening relative humidity (-0.183 and -0.289) and rainfall (-0.085 and -0.346) during *kharif* seasons of 2017-18 and 2018-19, respectively.

The overall linear multiple regression analysis was worked out between population of *H. armigera* on pigeonpea of W0 week with weather parameters of one week prior (W-1) for var Rajeshwari and D_2 sowing window (26th MW). The results obtained are given as follows.

The multiple regression equation is given below:

Y= -40.093 + 6.764 (T_{max}) – 3.264 (T_{min}) – 0.848 (RH I) + 0.025 (RH II) – 0.062 (Rainfall) – 4.638 (BSS).

An increase of one unit of maximum temperature and evening relative humidity increased the population of *H.armigera* by 6.764 and 0.025 units. These weather parameters collectively increased the population of *H. armigera* to an extent of 77.5 % (R^2=0.775).

During third sowing window 28th MW (D_3) with var Rajeshwari the population of *H. armigera* larvae per five plants for one week prior (W-1) was positively correlated with morning relative humidity (0.280 and 0.074) and bright sunshine hrs (0.092 and 0.074), whereas, it was negatively correlated with maximum temperature (-0.319 and -0.066) minimum temperature (-0.368 and -0.305), evening relative humidity (-0.187 and -0.275) and rainfall (-0.298 and -0.376) during *kharif* seasons of 2017-18 and 2018-19, respectively.

The overall linear multiple regression analysis was worked out between population of *H. armigera* on pigeonpea of W0 week with weather parameters of one week prior (W-1) for var Rajeshwari and D_3 sowing window (28th MW). The results obtained are given as follows.

The multiple regression equation is given below:

Y= – 49.356 + 5.557 (T_{max}) – 2.943 (T_{min}) – 0.423 (RH I) + 0.107 (RH II) – 0.113 (Rainfall) – 4.667 (BSS)

An increase of one unit of maximum temperature, evening relative humidity increased the population of *H. armigera* by 5.557 and 0.107 units, respectively. These weather parameters collectively increased the population of *H. armigera* to an extent of 85.7 % (R^2=0.857).

During fourth sowing window 30th MW (D_4) with var Rajeshwari the population of *H. armigera* larvae per five plants for one week prior (W-1) was positively correlated with morning relative humidity (0.277 and 0.183) and bright sunshine hrs (0.101 and 0.056), whereas, it was negative correlated with maximum temperature (-0.289 and -0.311) minimum temperature (-0.359 and -0.485), evening relative humidity (-0.210 and -0.223), rainfall (-0.283 and-0.466) and evaporation (0.214 and -0.200) during *kharif* seasons of 2017-18 and 2018-19, respectively.

The overall linear multiple regression analysis was worked out between population of *H. armigera* on pigeonpea of W0 week with weather parameters of one week prior (W-1) for var Rajeshwari and D_4 sowing window (30th MW). The results obtained are given as follows.

The multiple regression equation is given below:

Y= – 32.726 +3.776 (T_{max}) – 2.135 (T_{min}) + 0.274 (RH I) + 0.109 (RH II) – 0.092 (Rainfall) – 3.280 (BSS)

An increase of one unit of maximum temperature, morning relative humidity and evening relative humidity increased the population of *H. armigera* by 3.776, 0.274 and 0.109 units, respectively. These weather parameters collectively increased the population of *H. armigera* to an extent of 64.1 % (R^2=0.641).

Correlation between weather parameters and population of *H. armigera* larvae per five plants

on pigeonpea var BDN 711 at different sowing windows and forewarning models for prediction of incidence of *H. armigera*

During first sowing window 24th MW (D_1) with var BDN 711 the population of *H. armigera* larvae per five plants for one week prior (W-1) was positively correlated with bright sunshine hrs (0.329 and 0.469), whereas, it was negative correlated with minimum temperature (-0.438 and -0.049), evening relative humidity (-0.472 and -0.512) and rainfall (-0.251 and -0.249) during *kharif* seasons of 2017-18 and 2018-19, respectively.

The overall linear multiple regression analysis was worked out between population of *H. armigera* on pigeonpea of W0 week with weather parameters of one week prior (W-1) for var BDN 711 and D_1 sowing window (24th MW). The results obtained are given as follows.

The multiple regression equation is given below:

$$Y = -28.347 + 5.628 (T_{max}) - 2.682 (T_{min}) - 0.772 (RH I) - 0.102 (RH II) - 0.010 (Rainfall) - 3.111 (BSS)$$

An increase of one unit of maximum temperature increased the population of *H. armigera* by 5.628 units to an extent of 63.7 % (R^2=0.637).

During second sowing window 26th MW (D_2) with var BDN 711 the population of population of *H. armigera* larvae per five plants for one week prior (W-1) was positively correlated with bright sunshine hrs (0.151 and 0.189), whereas, it was negative correlated with minimum temperature (-0.287 and -0.168), evening relative humidity (-0.241 and -0.288) and rainfall (-0.259 and -0.368) during *kharif* seasons of 2017-18 and 2018-19, respectively.

The overall linear multiple regression analysis was worked out between population of *H. armigera* on pigeonpea of W0 week with weather parameters of one week prior (W-1) for var BDN 711 and D_2 sowing window (26th MW). The results obtained are given as follows.

The multiple regression equation is given below:

$$Y = -13.017 + 5.671 (T_{max}) - 3.193 (T_{min}) - 0.783 (RH I) - 0.027(RH II) - 0.061 (Rainfall) - 3.129 (BSS)$$

An increase of one unit of maximum temperature increased the population of *H. armigera* by 5.671 units to an extent of 64.8 % (R^2=0.648).

During third sowing window 28th MW (D_3) with var BDN 711 the population of population of *H. armigera* larvae per five plants for one week prior (W-1) was positively correlated with bright sunshine hrs (0.052 and 0.154), whereas, it was significant negative correlated with maximum temperature (-0.543 and -0.075) and negative correlated with minimum temperature (-0.492 and -0.305), evening relative humidity (-0.162 and -0.227) and rainfall (-0.373 and -0.400) during *kharif* seasons of 2017-18 and 2018-19, respectively.

The overall linear multiple regression analysis was worked out between population of *H. armigera* on pigeonpea of W0 week with weather parameters of one week prior (W-1) for var BDN 711 and D_3 sowing window (28th MW). The results obtained are given as follows.

The multiple regression equation is given below:

$$Y = -21.029 + 4.665 (T_{max}) - 3.172 (T_{min}) - 0.459 (RH I) + 0.145(RH II) - 0.068 (Rainfall) - 4.051 (BSS)$$

An increase of one unit of maximum temperature and evening relative humidity increased the population of *H. armigera* by 4.665 and 0.145 units, respectively. These weather parameters collectively increased the population of *H. armigera* to an extent of 69.1 % (R^2=0.691).

During fourth sowing window 30th MW (D_4) with var BDN 711 the population of population of *H. armigera* larvae per five plants for one week prior (W-1) was positively correlated with morning relative humidity (0.257 and 0.134) and bright sunshine hrs (0.120 and 0.067), whereas, it was significant negative correlated with maximum temperature (-0.714 and -0.275), minimum temperature (-0.583 and -0.458) and wind speed (-0.535 and -0.366) and negative correlated evening relative humidity (-0.205 and

-0.119), rainfall (-0.468 and -0.456) and evaporation (0.386 and -0.166) during *kharif* seasons of 2017-18 and 2018-19, respectively.

The overall linear multiple regression analysis was worked out between population of *H. armigera* on pigeonpea of W0 week with weather parameters of one week prior (W-1) for var BDN 711 and D_4 sowing window (30th MW). The results obtained are given as follows.

The multiple regression equation is given below:

$$Y= -2.869 +1.611(T_{max}) - 1.650 (T_{min}) + 0.011(RH\ I) + 0.088(RH\ II) - 0.084 (Rainfall) - 2.586 (BSS)$$

An increase of one unit of maximum temperature, morning and evening relative humidity increased the population of *H. armigera* by 1.611, 0.011 and 0.088 units, respectively. These weather parameters collectively increased the population of *H. armigera* to an extent of 68.7 % (R^2=0.687).

Correlation between weather parameters and population of *H. armigera* larvae per five plants on pigeonpea var ICPH 2740 at different sowing windows and forewarning models for prediction of incidence of *H. armigera*

During first sowing window 24th MW (D_1) with var ICPH 2740 the population of *H. armigera* larvae per five plants for one week prior (W-1) was positively correlated with bright sunshine hrs (0.329 and 0.469), whereas, it was negative correlated with minimum temperature (-0.438 and -0.049), evening relative humidity (-0.472 and -0.512) and rainfall (-0.251 and -0.249) during *kharif* seasons of 2017-18 and 2018-19, respectively.

The overall linear multiple regression analysis was worked out between population of *H. armigera* on pigeonpea of W0 week with weather parameters of one week prior (W-1) for var ICPH 2740 and D_1 sowing window (24th MW). The results obtained are given as follows.

The multiple regression equation is given below:

$$Y= -2.869 + 1.611 (T_{max}) - 1.650 (T_{min}) + 0.011 (RH\ I) + 0.088 (RH\ II) - 0.084 (Rainfall) - 2.586 (BSS)$$

An increase of one unit of maximum temperature, morning and evening relative humidity increased the population of *H. armigera* by 1.611, 0.011 and 0.088 units, respectively. These weather parameters collectively increased the population of *H. armigera* to an extent of 81.4 % (R^2=0.814).

During second sowing window 26th MW (D_2) with var ICPH 2740 the population of population of *H. armigera* larvae per five plants for one week prior (W-1) was positively correlated with bright sunshine hrs (0.151 and 0.189), whereas, it was negative correlated with minimum temperature (-0.287 and -0.168), evening relative humidity (-0.241 and -0.288) and rainfall (-0.259 and-0.368) during *kharif* seasons of 2017-18 and 2018-19, respectively.

The overall linear multiple regression analysis was worked out between population of *H. armigera* on pigeonpea of W0 week with weather parameters of one week prior (W-1) for var ICPH 2740 and D_2 sowing window (26th MW). The results obtained are given as follows.

The multiple regression equation is given below:

$$Y= 66.728 - 2.065 (T_{max}) - 0.553 (T_{min}) - 0.163 (RH\ I) + 0.141 (RH\ II) - 0.121 (Rainfall) + 0.547 (BSS)$$

An increase of one unit of evening relative humidity and bright sunshine hrs increased the population of *H. armigera* by 0.141 and 0.547 units to an extent of 72.8 % (R^2=0.728).

During third sowing window 28th MW (D_3) with var ICPH 2740 the population of population of *H. armigera* larvae per five plants for one week prior (W-1) was positively correlated with bright sunshine hrs (0.052 and 0.154), whereas, it was significant negative correlated with maximum temperature (-0.543 and -0.075) and negative correlated with minimum temperature (-0.492 and -0.305), evening relative humidity (-0.162 and -0.227) and rainfall (-0.373 and -0.400) during *kharif* seasons of 2017-18 and 2018-19, respectively.

The overall linear multiple regression analysis was worked out between population of *H. armigera* on pigeonpea of W0 week with weather parameters of one week prior (W-1) for var ICPH 2740 and D_3 sowing window (28th MW). The results obtained are given as follows.

The multiple regression equation is given below:

$$Y= 73.950 – 2.710 (T_{max}) – 0.642 (T_{min}) – 0.039 (RH I) + 0.103 (RH II) – 0.096 (Rainfall) + 0.689 (BSS)$$

An increase of one unit of evening relative humidity and bright sunshine hrs increased the population of *H. armigera* by 0.103 and 0.689 units, respectively. These weather parameters collectively increased the population of *H. armigera* to an extent of 77.1 % (R^2=0.771).

During fourth sowing window 30th MW (D_4) with var ICPH 2740 the population of population of *H. armigera* larvae per five plants for one week prior (W-1) was positively correlated with morning relative humidity (0.257 and 0.134) and bright sunshine hrs (0.120 and 0.067) whereas, it was significant negative correlated with maximum temperature (-0.714 and -0.275), minimum temperature (-0.583 and -0.458) and wind speed (0.535 and 0.366) and negative correlated evening relative humidity (-0.205 and -0.119), rainfall (-0.468 and -0.456) and evaporation (0.386 and -0.166) during *kharif* seasons of 2017-18 and 2018-19, respectively.

The overall linear multiple regression analysis was worked out between population of *H. armigera* on pigeonpea of W0 week with weather parameters of one week prior (W-1) for var ICPH 2740 and D4 sowing window (30th MW). The results obtained are given as follows.

The multiple regression equation is given below:

$$Y= 76.411 – 2.929 (T_{max}) + 0.691 (T_{min}) – 0.039 (RH I) + 0.103 (RH II) – 0.072 (Rainfall) +1.048 (BSS)$$

An increase of one unit of minimum temperature, evening relative humidity and bright sunshine hrs increased the population of *H. armigera* by 0.691, 0.103 and 1.048 units, respectively. These weather parameters collectively increased the population of *H. armigera* to an extent of 68.8 % (R^2=0.688).

Shinde *et al*. (2017) investigated that the correlation of *H. armigera* population with maximum temperature, minimum temperature and evening relative humidity were positively non-significant whereas, morning relative humidity negatively non-significant. Were the co-efficient of multiple regression was non-significant in all-weather parameters. The selected weather parameter indicated 55.9 % variation in the infestation of *H. armigera*. Similar results were reported by Pawar *et al*. (2007),Jakhar *et al.* (2016), Sagar *et al.* (2017), Puran *et al*. (2017).

CONCLUSION

The population of larvae was increased gradually from 39th MW to 48th MW. The highest populations of larvae were 15.69 and 13.84 per five plants recorded, during 2017-18 and 2018-19, respectively, observed in var BDN 711.The correlation of weather parameters with seasonal incidence of *H. armigera* found to have positively correlation with morning relative humidity and bright sunshine hours whereas, maximum temperature, minimum temperature and rainfall showed negative. Prediction of *H. armigera* larvae populations one week prior (W-1) in different sowing windows based on regression equations recorded (R^2) 53.6 to 87.4% validation for var Vipula, (R^2) 61.3 to 85.7% validation for var Rajeshwari, (R^2) 58.4 to 76.4 % validation for var BDN 711 and (R^2) 68.8 to 81.4% validation based on different weather parameters for var ICPH 2740.

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