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Monitoring *Helicoverpa armigera* (Hubner) through Pheromone and Light Traps and its Population Dynamics in Relation to Weather Parameters in Pigeonpea Ecosystem

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ABSTRACT

Monitoring of *H. armigera* moths through sex pheromone and light traps were carried out in pigeonpea ecosystem at Zonal Agricultural Research Station, University of Agricultural Sciences, Bangalore during 2019-20 and 2020-21. The results revealed that, activity of the noctuid moth, *H. armigera* started from 35th and 36th standard Meteorological Week (SMW), wherein, the mean moth catches were found to be 0.5 ± 0.71 and 0.5 ± 0.71moths / trap / week, respectively. After wards, its peak observed was 6.25 ± 0.35 moths / trap / week which was recorded during 47th SMW in 2019-20. Later, it was followed by a gradual drop in activity of moth population. During second year, moth was first observed in 36th SMW (0.25 ± 0.71 moths / trap / week) and reached its peak at 48th SMW (7.25 ± 0.35 moths / trap / week), which was followed by a gradual decline in the moth activity. Abiotic factors *viz*., rainfall, morning and evening relative humidity and minimum temperature had negative correlation with moths population catches, whereas, wind speed had significant negative correlation. Similarly, positive correlation had been observed with respect to maximum temperature, bright sunshine hour and evaporation during 2019-20. On the contrary, during 2020-21 moth catches showed negative correlation with rainfall, maximum temperature, minimum temperature and bright sunshine hours. Conversely, morning and evening relative humidity, wind speed and evaporation were found to be positively correlated with moth catches.

Keywords : Monitoring, *H. armigera*, Rraps, Weather parameters

PIGEONPEA (*Cajanus cajan* L.), also popularly known as arhar or red gram is domesticated at least 3,500 years ago in the Indian subcontinent. Pigeonpea is cultivated in more than 25 tropical and subtropical countries, either as a sole crop or intermixed with cereals or legumes. It is having unique nutritional property containing high levels of protein and carbohydrates along with trace of vitamins and minerals. Also being a legume, it has symbiosis with *Rhizobia* bacteria which enrich soils through symbiotic nitrogen fixation. Production of pigeopea in the world is estimated at 4.42 million tons of which nearly 74 per cent comes from India (FAO, 2019).

Insect pests are the major bottle necks in realizing the yield potentiality in pigeopea crop and the most important pest among them is the pod borer, *Helicoverpa armigera* (Hubner). It is present throughout the year, has a wide host range of 360 species and cultivated crops. Tomato, cotton, pigeonpea, chickpea, okra, sorghum, cowpea and range of vegetables suffer severely by *H. armigera* damage (Anonymous, 2006). *Helicoverpa* causes heavy losses up to 60 per cent accounting to US $ 400 Million annually (Anonymous, 2011). *H. armigera* is also reported as a major pest on chickpea, mungbean, urdbean, lentil and soybean (Ranvir and Jagadish, 2018). Integrated Pest Management (IPM) approach is the most appropriate mode of managing this pest. Monitoring through pheromone traps and light traps are the important components in IPM programme facilitating judicious use of pesticides based on economic threshold level.

Recent climatic changes have influenced the density of *H. armigera* population in different pulse crops. Understanding the pest-weather relationship is of paramount importance for effective pest suppression.

Pest population level may be dependent on weather parameters thus it becomes important to explore relationship of pest population. In this context, the present investigation was carried out to monitor and assess the incidence of *H. amigera* in pegion pea crop in Southern Karnataka region of India.

Material and Methods

The experiments were carried out during 2019-20 and 2020-21 at Zonal Agriculture Research Station, University of Agricultural Sciences, Bangalore, in *kharif* seasons. The pegion pea variety BRG 5 was sown by following all the agronomic practices which were adopted as per the package of practice of University of Agricultural Sciences, Bangalore, Karnataka, for pegion pea crop. The adult population was monitored by erecting sleeve type pheromone trap in each block on poles at 1.2 m height above the ground level @ 5/ha. In pheromone traps helico-lure were replaced with new ones after every 30 days. The SMB solar light trap with light source which wave length is 390 nm-600 nm was also used to monitor moth population. The data on adult trap catches of *H. armigera* were recorded at weekly intervals up to the harvest of crop and expressed as mean number of moths / trap / week.

Weather parameters such as temperature (maximum-TMax and minimum-TMin), relative humidity (morning- RH1 and evening-RH2), rainfall (RF), bright sunshine hours (BSSH), wind speed (WS) and evaporation (Evp.) data were obtained from Department of Agro-Meteorology of University Agricultural Sciences, Bangalore. The data collected was computed using simple correlation analysis by using the weather parameters with moth catches to know the influence of different abiotic factors. Further, co-relation co-efficients were used to explain the impact of weather parameters on the incidence of *H. armigera*. For statistical analysis and graphical representation SPSS and R software programme was used.

Results and Discussion

The data on moth catches of *H. armigera* in pheromone and solar light trap along with weather parameters is presented under the following headings.

Population Fluctuation of *H. armigera* in Pheromone and Light Traps during 2019-20 and 2020-21

The population fluctuation of *H. armigera* was studied based on the moth catches per trap. During the first season of experimentation *i.e.,* 2019-20, the moth was first observed on last week of August (35th SMW - standard meteorological week) with minimum mean population of 0.5 ± 0.71 (mean ± standard deviation) per trap / week, then increased followed by decreased in the moth catches on 36th and 37th SMW, respectively. Later the population showed an increasing trend after 40th SMW (1stweek of October). During 47th SMW (3rd week of November) the maximum moth catches of 6.75 ± 0.35 moths / trap / week was recorded. However, after 48th SMW the moth population showed declining trend and gradually dwindled as the crop started reaching maturity (Table 1). The light traps used for recording the moth population also followed the same trend in the increasing and decreasing pattern when crop reaches maturity stage. The light trap data also revealed that initial occurrence of the pest was observed during the last week of August considered on 35th SMW (1 moth / trap / week) and the maximum population (6 moth / trap / week) was observed during 47th SMW (3rd week of November). Thereafter, moth population declined gradually when the crop started reaching towards maturity stage (Table 1). The results of moth catches in pheromone trap were in accordance with the reports of Basavaraj *et al.*, 2013; Divyasree *et al.*, 2021 and Ingale *et al.*, 2018 who reported that extreme adult activity of *H. armigera* on pigeonpea was during mid-October to November. In the light trap studies, similar findings of noctuid moth catches during October to November was reported by Divyasree *et al.* (2021).

Similarly, during the second year of experimentation in 2020-21, where the noctuid moth was first observed

TABLE 1

Helicoverpa armigera moth activity monitoring data using sex pheromone trap at ZARS, Bengaluru during pigeonpea crop growth period in 2019-20

Date	SMV	Rainfall (mm)	Rel. Hum.(%)		Temperature (°C)		Speed (Km/day)	Bright SSH (Hr.)	Evap. (mm)	No. of moths /trap/week	
			Morning	Evening	Max.	Min.				Pheromone trap	Light trap
20th Aug. 2019	34	74.0	93	63	27.3	17.9	7.1	3.5	2.8	0.0 ± 0.00	0
27th Aug.	35	56.0	95	62	27.4	18.1	8.2	4.4	2.8	0.5 ± 0.71	0
03rd Sept.	36	24.0	91	60	28.0	18.7	9.3	5.7	4.2	1.5 ± 0.71	1
10th Sept.	37	5.4	93	61	27.1	18.3	10.5	0.8	3.2	2.0 ± 1.41	2
17th Sept.	38	4.0	91	54	28.9	18.9	7.5	5.0	4.1	1.75 ± 0.35	3
24th Sept.	39	113.0	92	59	27.7	18.6	5.0	3.6	3.3	2.5 ± .71	3
01st Oct.	40	64.2	91	56	28.2	18.4	5.5	5.3	3.4	2.75 ± 0.35	3
08th Oct.	41	76.2	92	54	29.2	18.3	3.8	6.0	3.9	3.75 ± 0.35	4
15th Oct.	42	71.8	91	54	28.9	18.7	2.2	5.3	4.1	2.75 ± 0.35	4
22nd Oct.	43	12.0	92	62	27.4	18.6	6.1	5.7	3.6	3.3 ± 0.71	4
29th Oct.	44	70.2	94	61	26.3	17.9	5.3	3.4	2.7	4.5 ± 0.71	5
05th Nov.	45	3.8	93	58	26.9	16.7	5.8	5.4	2.9	4.5 ± 0.71	5
12th Nov.	46	0.4	89	55	28.8	17.3	2.9	7.6	4.0	5.25 ± 0.35	7
19th Nov.	47	1.8	91	59	27.2	17.1	5.3	7.3	3.9	6.25 ± 0.35	5
26th Nov.	48	8.2	90	58	27.2	17.2	6.7	4.4	3.7	4.5 ± 0.71	4
03rd Dec.	49	1.6	93	64	25.9	16.7	8.3	3.9	3.3	3.75 ± 1.06	3
10th Dec.	50	0.0	93	68	24.4	16.3	7.9	3.2	3.0	3.0 ± 1.41	3
17th Dec.	51	0.0	90	62	26.4	15.8	7.1	6.0	3.8	2.5 ± 0.71	1
24th Dec.	52	0.0	90	60	26.3	15.9	7.5	6.0	3.7	1.75 ± 0.35	1
31st Dec.	52	0.0	91	56	27.5	17.2	5.9	5.9	4.1	0.5 ± 0.71	0
07th Jan. 2020	1	11.6	91	61	26.4	16.6	7.0	5.2	3.6	0.0 ± 0.00	0

* SMW= Standard Meteorological Week

TABLE 2

Helicoverpa armigera moth activity monitoring data using light trap at ZARS, Bengaluru during pigeonpea crop growth period in 2020-21

Date	SMV	Rainfall (mm)	Rel. Hum.(%)		Temperature (°C)		Speed (Km/day)	Bright SSH (Hr.)	Evap. (mm)	No. of moths /trap/week	
			Morning	Evening	Max.	Min.				Pheromone trap	Light trap
28 Aug. 2020	35	1.0	92.4	54.9	28.5	19.1	4.1	4.5	4.5	0.00 ± 0.00	0
04 Sept. 2020	36	80.8	91.3	56.7	28.9	18.9	4.2	6.2	3.6	0.25 ± 0.00	0
11 Sept. 2020	37	102.0	92.3	55.9	28.8	19.3	5.1	6.0	3.3	0.75 ± 0.35	1
18 Sept. 2020	38	4.0	93.9	61.7	26.3	18.2	7.8	1.7	2.6	1.50 ± 0.71	2
25 Sept. 2020	39	8.0	93.3	60.7	26.8	18.5	8.4	3.6	3.0	2.25 ± 1.06	3
02 Oct. 2020	40	49.4	93.4	62.3	27.1	18.5	5.5	3.7	3.3	2.50 ± 0.71	3
09 Oct. 2020	41	6.8	93.0	54.3	28.5	18.6	5.0	7.4	4.3	2.50 ± 0.71	3
16 Oct. 2020	42	27.0	89.7	65.3	26.4	18.0	6.5	1.7	3.7	3.75 ± 0.35	4
23 Oct. 2020	43	82.6	94.1	63.0	26.6	18.7	2.9	2.4	3.6	4.00 ± 0.00	4
30 Oct. 2020	44	9.0	94.1	61.3	27.2	17.5	3.3	5.8	3.8	4.25 ± 0.35	4
06 Nov. 2020	45	42.0	90.3	56.6	28.8	18.3	4.0	7.2	4.0	5.00 ± 0.00	5
13 Nov. 2020	46	5.0	92.0	62.6	27.2	17.6	6.6	7.4	3.7	5.25 ± 0.35	5
20 Nov. 2020	47	11.0	94.6	61.7	26.5	18.1	8.3	1.8	3.4	6.25 ± 0.35	7
27 Nov. 2020	48	17.0	93.7	67.0	26.2	16.2	7.0	5.9	3.5	7.25 ± 0.35	5
04 Dec. 2020	49	1.4	92.5	68.0	25.3	16.1	6.7	4.9	3.3	4.75 ± 00	4
11 Dec. 2020	50	0.0	96	60	26.2	17.0	7.4	4.9	3.3	4.50 ± 00	3
18 Dec. 2020	51	0.0	94.6	63.9	25.8	15.6	4.4	8.1	3.4	2.50 ± 0.71	3
25 Dec. 2020	52	0.0	91.0	63.6	26.1	14.9	7.0	6.8	3.5	1.25 ± 0.35	1
01 Jan. 2021	1	0.0	91.8	59.7	27.4	15.5	6.0	9.3	3.8	0.75 ± 0.35	1

on 36th SMV (1stweek September) with the initial low mean moth catches of 0.25 ± 0.00 / trap/ week (Table 2) and the moth population showed increasing trend after 37th SMW (2nd week of September). In the course of 48th SMW (last week of November) the maximum moth catches were recorded (7.25 ± 0.35 moths / trap / week), then it was followed by gradual wane in the moth catches when, the crop at the end of harvesting stage activity of moth was not perceived. Accordingly, in the light trap population of moth, *H. armigera* was collected and its howed that initial occurrence of *H. armigera* was observed during 37th SMW (second week of August) with mean population of 1 moth / trap / week and the maximum population (7 moth / trap / week) was observed during 47th SMW (3rd week of November). Thereafter, the moth catches fall off gradually at maturity stage with no activity at the end of harvesting stage (Table 2). Similar type of moth population fluctuation was recorded by Basavaraj *et al*. (2013), who found that maximum activity of moth catches from mid-November to 1st week of December because it coincides with reproductive stage where the pod formation occurs that will predominantly preferred by its larva and decreased moth catches was from December 2nd week onwards by that time crop started reaching pod maturity stage where moth fails to lay eggs ultimately lead to decrease in upcoming generation. Ingale *et al*. (2018) and Divyasree *et al*. (2021) found that the maximum moth population during second fortnight of October to November which were accordance with present findings.

Influence of Weather Parameters on Moth Catches of *H. armigera*

The effect of different weather parameters on the population fluctuations of *H. armigera* in pigeonpea ecosystem was assessed on the basis of correlation analysis. The moth was correlated with abiotic factors such as rainfall, relative humidity (maximum and minimum), temperature (maximum and minimum), wind speed, sunshine hours and evaporation during both the years of experimentation *i.e.,* 2019-20 and 2020-21.

During 2019-20, the moth catches exhibits a non-significant positive correlation with maximum temperature (r = 0.049), bright sunshine hours (r = 0.276) and evaporation (r = 0.057). Whereas, non-significant negative correlation were establishes with rainfall (r = -0.129), morning relative humidity (r = - 0.139) and evening relative humidity (r = -0.169) and minimum temperature (r = -0.069) similarly, significant negative correlation was in between wind speed (r = 0.443) and moth catches (Table 3).

Correspondingly, during the next season of experimentation in 2020-21, the moth catches exhibited a non-significant positive correlation with morning relative humidity (r = 0.197) and evening relative humidity (r = 0.121), wind speed (r = 0.290) and evaporation (r = 0.366). The weather parameters *i.e.,* the rainfall (r = - 0.105), maximum temperature (r = -0.226), minimum temperature (r = -0.034) and bright sunshine hours (r = -0.075) which showed negative non-significant effect on the *H. armigera* moth population (Table 3).

The effect of different weather parameters on the population fluctuations of *H. armigera* moth catches in pooled data of 2019-20 and 2020-21 on pegionpea revealed that non-significant positive correlation with morning relative humidity (r = 0.106) and evening relative humidity (r = 0.138), bright sunshine hours

TABLE 3

Correlation between moth populations of *H. armigera* and weather parameters on pigeonpea

Weather parameters	2019	2020	Pooled data
Rainfall (mm)	-0.129	-0.105	-0.117
Morning Relative humidity (%)	-0.139	0.290	0.106
Evening Relative humidity (%)	-0.169	0.366	0.138
Maximum Temperature (°C)	0.049	-0.226	-0.105
Minimum Temperature (°C)	-0.069	-0.034	-0.048
Wind Speed (km/hr.)	-0.448*	0.121	-0.159
Bright Sunshine Hours (hrs.)	0.276	-0.075	0.051
Evaporation (mm)	0.057	0.197	0.121

* Correlation is significant at the 0.05 level

(r = 0.051) and evaporation (r = 0.121). Whereas, in the different weather factors *viz.*, rainfall (r = -0.117), maximum temperature (r = -0.105), minimum temperature (r = -0.048) and wind speed (r = -0.121) unveiled non-significant negative correlation with moth catches in pegionpea ecosystem. The results were in line with Sagar *et al*. (2017), found that non-significant negative association in between moth catches and morning and evening relative humidity, significant positive association in wind speed which was seen in the present findings during 2019-20 but contradicted to wind speed. Sharma *et al.* (2012) and Divyasree *et al*. (2021) reported that relative humidity had negative correlation with *H. armigera*. The present findings also followed the results of Sandeep *et al.* (2017) found that relative humidity had negative association, bright sunshine hours and maximum temperature had positive correlation with moth catches in 1st year (Fig. 2a) and wind speed had positive association with moth catch in 2nd year (Fig. 2b), whereas, positive correlation between *H. armigera* moth and evaporation was seen in both years on pegion pea. In pooled values of moth catches when correlated with weather parameters Suresh *et al.,* 2018 found that moth catches had negative correlation with maximum temperature, wind speed and bright sunshine hour and had positive correlation with rainfall, morning and evening relative humidity and minimum temperature which were following the current study results but discordant correlation noticed in the moth catches (Fig. 2c) with minimum temperature, rainfall and bright sunshine hours that may due to change in the weather factors in particular locations.

Weather based regression equation was developed by taking moth catches of *H. armigera* (y) as a dependent variable and weather parameters (x) as independent variable (Table 4). The regression coefficient revealed that the various abiotic factors were found to be most influencing factor, which contributed (R2 = 0.711, 0.940 and 0.717) 71.1, 94.0 and 71.7 per cent variations in moth catches of *H. armigera* during 2019, 2020 and pooled years, respectively.

From the regression equation in pooled years of 2019 and 2020, it could be deduced that for every 1 mm increase in RF the male moth catches of *H. armigera* decreased by 0.042 per trap per week, while increase in RH1 by 1 per cent decreased the trap catches by 0.049 per trap per week. Likewise, increase in RH2 by 1 per cent decreased the trap catches by 0.049 per trap per-week likewise the explanation for remaining weather factors. The coefficient of determination (R2 = 0.717) indicated that 71.7 per cent variability in male moth catches of *H. armigera* was accounted by different weather factors. Earlier Keval *et al.* (2017) reported that 89.6 per cent during 2015-16 and 8634 per cent during 2016-17 due to various

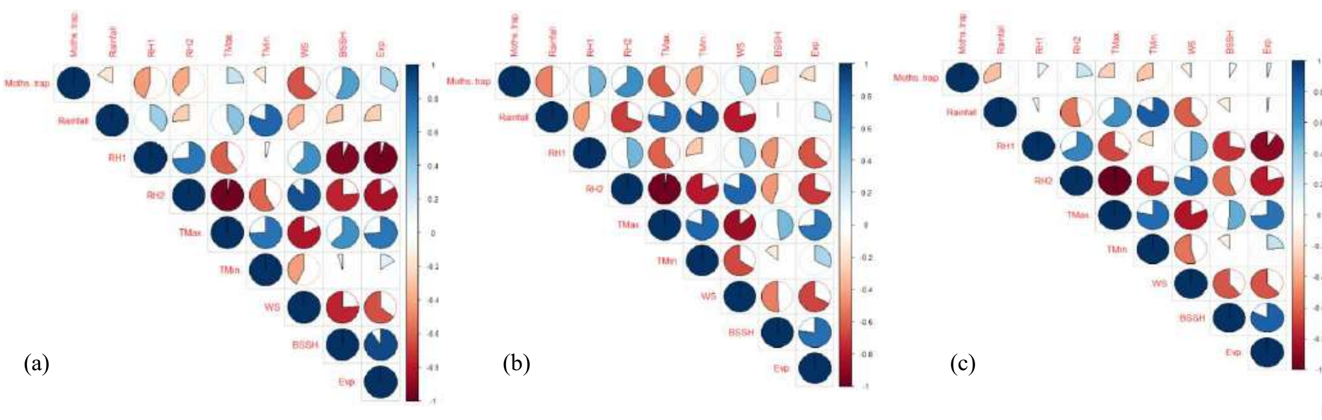

Fig. 2 : Correlation of trap catches of *H. armigera*moths with different weather parameters on corroplot: (a) 2019-20, (b) 2020-21, (c) Pooled data.

Note: RF-Rain fall, RH1- morning relative humidity, RH2- evening relative humidity, TMax- maximum temperature, TMin- minimum temperature, WS- wind speed, BSSH- bright sunshine hours, Evp.- evaporation.

TABLE 4

Regression equations showing impact of weather parameters on trap catches of *H. armigera* moths on pigeonpea

Year	Regression Equation	R^2
2019	$Y = 48.431 - 0.042 (X_1) - 0.049 (X_2) - 0.222 (X_3) - 1.174 (X_4) + 0.862 (X_5) - 0.894 (X_6) + 0.025 (X_7) - 1.087 (X_8)$	0.711
2020	$Y = -25.495 - 0.04 (X_1) - 0.080 (X_2) - 0.119 (X_3) - 0.274 (X_4) + 0.214 (X_5) - 0.045 (X_6) - 0.006 (X_7) + 0.997 (X_8)$	0.940
pooled	$Y = 32.641 - 0.018 (X_1) - 0.032 (X_2) - 0.125 (X_3) - 0.861 (X_4) + 0.361 (X_5) - 0.563 (X_6) + 0.080 (X_7) + 0.949 (X_8)$	0.717

***Note** - X_1 = Rainfall (mm), X_2 = Morning Relative humidity (%), X_3 = Evening Relative humidity (%), X_4 = Maximum Temperature (°C), X_5 = Minimum Temperature (°C), X_6 = Wind Speed (Km/hr.), X_7 = Bright Sunshine Hours (hrs.) and X_8 = Evaporation (mm)

weather factors in pegionpea. Ramesh Babu *et al.* (2009) and Sagar *et al.* (2017) also reported that 88.08 and 77.9 per cent variations, respectively in male moth catches of *H. armigera* in chickpea crop. In the coefficient of determination (R2 = 0.717) in pooled years of 2019 and 2020, stepwise regression to find out the significant weather factor influencing male moth catches of *H. armigera*. Hence, the stepwise regression equation as Y = 5.637 + 0.917 (EVP) - 0.587 (WS) - 0.023 (RF) - 0.257 (BSSH) [R2 = 0.696]. By stepwise regression, WS, EVP, RF and BSSH were found to be important factors that influenced the trap catches of *H. armigera*. Earlier Sagar *et al.* (2017) also reported BSSH is also significant weather factor influencing on moth catches of *H. armigera*. It has also been observed earlier report of Pinnschmid *et al.*, 1995 and Teng. *et al.*, 1998 that even if empirical pest-weather models had contributed significantly in apprehension of pest population dynamics but these were governed by local conditions and thus behaved in a location-specific manner.

It is concluded from the above findings that farmer should be alert during last week of October to second week of November, where the activity of the pest will be at its peak, which coincides with flowering stage of the crop. It is also concluded that significant correlation exists between wind speed and *Helicoverpa* moth catches in pegionpea ecosystem. The information generated in the present study gives an indication about the importance of the different weather parameters in developing weather based forecasting models for successful development and implementation of the pest management strategies against insect pests of pigeonpea for increasing production efficiency and profit besides safety to the environment.

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REFERENCES

ANONYMOUS, 2006, Crop Protection Compendium. *CAB International*, Wallingford, UK.

ANONYMOUS, 2011, The medium term plan. ICRISAT, Patancheru, Andhra Pradesh, India, pp. : 3.

BASAVARAJ, K., GEETHA, S., JAGDISH, K. S., MOHAN NAIK, I. AND SHADAKSHARI, Y. G., 2013, Influence of meteorological factors on sex pheromone trap catches of *Helicoverpa armigera* (Hub.) and *Spodoptera litura* (Fab.) in sunflower (*Helianthus annus* L.). *Curr. Biotica*, **7** (3) : 174 - 182.

DIVYASREE, C., SREEKANTH, M., CHIRANJEEVI, C. H. AND ADINARAYANA, M., 2021, Monitoring of *Helicoverpa armigera* through pheromone and light traps on pigeonpea and impact of weather parameters on trap catch. *Int. J. Chem. Stud.*, **9** (3) : 170 - 173.

FAOSTAT, *www.fao.org. Retrieved 2019.*

INGALE, R. T., KADAM, D. R., SAVDE, V. G. AND MANE, U. T., 2018, Seasonal incidence of *Helicoverpa armigera* (Hubner) and *Exelastis atomosa* (Walsingham) on different cultivars of pigeonpea. *Int. J. Chem. Stud.*, **6** (5) : 1084 - 1088.

PINNSCHMIDT, H. O., BATCHELOR, W. D. AND TENG, P. S., 1995, Simulation of multiple species pest damage on rice. *Agric. Systems*, **48** : 193 - 222.

RANVIR, S. AND JAGADISH, K. S., 2018, Bio-efficacy of different geographical isolates of *Helicoverpa armigera* nucleo polyhedrosis virus (HaNPV) against gram pod borer, *Helicoverpa armigera* (Hubner) in Pigeonpea. *Mysore J. Agric. Sci*., **52** (2) : 158 - 165.

SAGAR, D., SURESH, M., NEBAPURE AND CHANDER, S., 2017, Development and validation of weather based prediction model for *H. armigera* in chickpea. *J. Agromet.*, **19** (4) : 328 - 333.

SANDEEP, C., SRIVASTAVA, P. AND SABUJ, G., 2017, Monitoring of *Helicoverpa armigera* (hubner) through pheromone traps in long duration pigeonpea [*Cajanus cajana* (L.) mill sp] under agroclimatic conditions of eastern U.P. *J. Exp. Zool.,* **20** (1) : 1567 - 1571.

SHARMA, P. K., KUMAR, U., VYAS, S., SHARMA, S. AND SHRIVASTAVA, S., 2012, Monitoring of *Helicoverpa armigera* (Hubner) (Lepidoptera: Noctuidae) through pheromone traps in chickpea (*Cicerarietinum*) crop and influence of some abiotic factors on insect population. *J. Environ. Sci. Toxicol. Food Tech.,* **1** (5) : 44 - 46.

SURESH, M. NEBAPURE, D. SAGAR AND SUBHASH, C., 2018, Population dynamics of insect pests on short duration pigeon pea in relation to weather parameters. *J. Agromet.,* **20** (3) : 234 - 237.

TENG, P. S., BATCHELOR, W. D., PINNSCHMIDT, H. O. AND WILKERSON, G. G., 1998, Simulation of pest effects on crops using coupled pest-crop models: the potential for decision support, pp. 221 - 226.

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