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Population dynamics of tomato fruit borer *Helicoverpa armigera* Hubner in relation to abiotic factors in central U.P.

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Abstract
A field experiment was conducted at Chandra Shekhar Azad University of agriculture and technology Kanpur (U.P) on tomato crop to study the population of *Halicoverpa armigera* and their relation with weather parameters during rabi season 2018-19 and 2019-20. Initial incidence of the pest was observed on 30.12.2019, in 52th standard week i.e., with a mean number of fruit infestation of 0.05. Thereafter the population of *Halicoverpa armigera* increase with increase in temperature during winter season. The fruit damage reached to peak by March 26, 2019 when the temperature increases and favorable for insect growth and development with mean larval population of 2.88 during 14th standard week. The results indicated positive significant correlation association between the maximum temperature (r= 0.503*), (r= 0.402*) and minimum temperature (r = 0.613**), (r= -0.419*) with the larval population prevailing during this period and positive significant association with morning or maximum relative humidity (r = 0.664**), (r=-0.692**) and negative non significant association with evening or minimum relative humidity (r = -0.008**), (r=-0.004**) with the larval population. The correlation relationship was negative and non-significant with rain fall and wind speed i.e. (r = - 0.164**), (r = - 0.180**) and (0.792**), (r = - 0.168**) respectively. The correlation between larval population and sun shine hrs was positively significant i.e. (r = 0.491*), (r = 0.238*).

Keywords: *Helicoverpa armigera*, population, correlation, weather, temperature, humidity

Introduction
Vegetables play an important role in human day-to-day diet. It is almost a well-known fact that out of nearly 300 commercially grown crops in the world about half are vegetables and they produce the maximum quantity of food per unit area. Tomato, *Lycopersicon esculentum* Mill.is one of the most popular and widely grown vegetable in the world. In India, it is grown in 814 (000) million ha. area with 20,515 (000) million tones production and 25.20 t/ha productivity. In India, Andhra Pradesh contributed maximum production (2845.64 MT) and share 13.87% of total state production but highest productivity was occupied by Maharashtra (28.20 tons/ha). (Source: All India (First Estimates), Department of Agriculture, Cooperation and Farmers welfare report 2018) [1]. In U.P., tomato grown in an area of about 21.2 million hectare and production is about 832.50 million tons (Source: State Departments of Horticulture & Agriculture annual report 2017-18). Tomato, *Lycopersicon esculentum* Mill. belongs to solanaceae, is of the most important vegetable crop of India called protective food. Food value of tomato is very rich because of higher contents of vitamins A, B and C including calcium and carotene (Bose and Som, 1990) [2]. Tomato contains 94 g water, 0.5 g minerals, 0.8 g fibre, 0.9 g protein, 0.2 g fat and 3.6 g carbohydrate and other elements like 48 mg calcium, 0.4 mg iron, 356 mg carotene, 0.12 mg vitamin B-1, 0.06 mg vitamin B-2 and 27 mg vitamin C in each 100 g edible ripen tomato (BARI, 2010) [3]. Tomato is susceptible to insect attack from seedling stage to fruiting stage. All parts of the plants including leaves, stem, flowers and fruits are subjected to attack. The production and productivity of tomato is severely hampered by various insect-pests and diseases infesting at different stages of crop growth, hence to produce healthy and good tomatoes and make it available to the consumers is a tedious task. Mandloi *et al.*, (2015) [4] reported that the production and quality of tomato fruits are considerably affected by array of insect pests infesting at different stages of crop growth. The key insect pests of tomato include Aphid (*Aphis gossypii* Glover), Jassid (*Amrasca devastans* Ishida), White fly (*Bemisia tabaci* Genn.), Leaf miner (*Liriomyza trifolii* Burgess), Thrips (*Scirtothrips dorsolis* Hood) and Fruit borer (*Helicoverpa armigera* Hub.) etc. Tomato fruit borer is a highly polyphagous and polymorphous pest infesting more than

400 agricultural and horticultural crops. Several vegetable crops like tomato, cabbage, cauliflower, chillies, brinjal, potato, etc. (Technical bulletin IIVR- 2014). The tomato fruit borer, *Helicoverpa armigera* (Hub.) is a key pest as it infests cashable part of the plant i.e. fruits and makes them unfit for human consumption causing considerable 55% crop loss. It has been estimated that crops worth Rs.1000 crore are lost annually by this pest. (Kumar *et al.* 2017) [5].

Materials and Methods:

The field experiment entitled "To study the population dynamics of *Helicoverpa armigera* Hubner in tomato in relation to abiotic factors of central U.P.*"* were conducted in Rabi season during 2018-2019 and 2019-2020 in the Student Instructional Farm (SIF) at Chandra Shekhar Azad University of Agriculture and Technology, Kanpur. The transplanting was done on 1 November 2018 and 5 November 2019, for both the year. For present experiment 20-25 old days seedlings of tomato variety Azad T-5 were transplanted in the field. The experiment was laid out in Completely Randomized Block Design (CRBD) having eight treatments including one control and replicated thrice. The tomato seedlings were transplanted in 4.5 × 3 m^2 plots with 75×60 cm spacing and all the recommended agronomical practices were followed to raise the crop. Single seedling was transplanted at a single spot and a light irrigation was provided after transplanting of the seedlings. Only the healthy plants were allowed to grow and weaker and dead plants were replace by gap filling process after one week of transplanting.

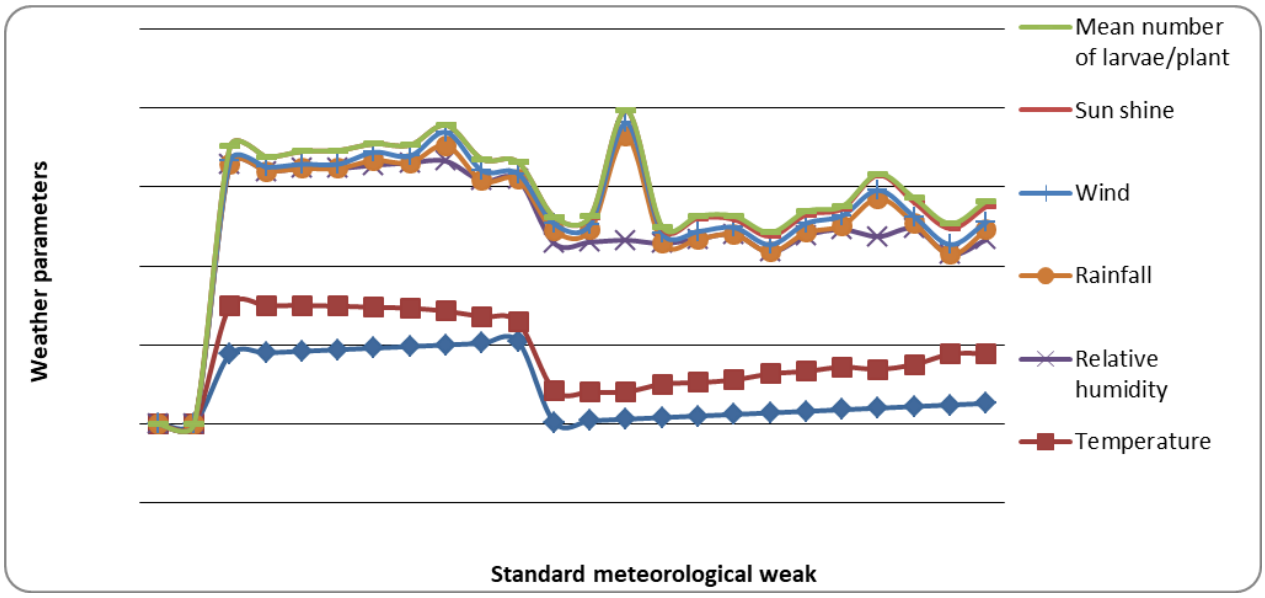
Result and discussion

Larval intensity of *Helicoverpa armigera* and corresponding periodical meteorological data during 2018-19

The incidence of *H. armigera* on tomato was recorded at regular weekly interval from the 20 randomly selected plants of the experimental field and correlated with the corresponding meteorological data to understand the relationship between them during the season. The population intensity of *H. armigera* was also observed throughout the cropping season from 01.11.2018 to 31.03.2019. Initial incidence of the pest was observed on 30.12.2019, in 52th standard week i.e., with a mean number of fruit infestation of 0.05. Due to the cold weather conditions at that particular time the average maximum and minimum temperature prevailed during the initial infestation were 21.00 ºC and 4.50 ºC, respectively and average morning and evening relative humidity was 87.30 and 34.20 per cent, respectively. The wind speed prevailing during this week was 3.70 km/h. The sun shine was 8:30 hrs/ day during this period. The fruit damage reached to peak by March 26, 2019 when the temperature increases and favorable for insect growth and development with mean larval population of 2.88 during 14th standard week. The average maximum and minimum temperature prevailing during this period were 36.70 ºC and 16.70 ºC, respectively in the 14th SW. Morning and evening relative humidity was 69.20 and 33.70, per cent, respectively. The average wind speed was observed during 14th standard week was 5.60 km/hr and sunshine 10.20 hrs in a day which was favorable for insect population. Relationship between larval population and major weather parameter during the crop period were also worked out through correlation coefficient by statistical analysis. The results indicated positive significant correlation association between the maximum temperature (r= 0.503*) and minimum temperature (r = 0.613**) with the larval population prevailing during this period and positive significant association with morning or maximum relative humidity (r = -0.664**) and negative non significant association with evening or minimum relative humidity (r = -0.008) with the larval population. The correlation relationship was negative and non-significant with rain fall and wind speed i.e. (r = - 0.164) and (0.792**), respectively. The correlation between larval population and sun shine hrs was positively significant i.e. (r = 0.491*).

Table 1: Larval intensity of *Helicoverpa armigera* and corresponding periodical meteorological data during 2018-19

Standard Meteorological Week	Temperature (^{0}C)		Relative Humidity (%)		Rainfall	Wind speed	Sun shine	Mean no. of larvae/plant
	(Max.)	(Min.)	(Max)	(Min)	(mm)	(km/h)	hrs/day	
44	32.10	15.15	81.50	39.00	0.00	2.10	9.00	0.00
45	28.30	12.70	82.40	44.00	0.00	2.60	6.50	0.00
46	29.50	10.60	84.00	34.20	0.00	2.70	8.10	0.00
47	28.40	11.50	84.50	34.10	0.00	2.70	8.60	0.00
48	26.60	10.50	90.10	44.40	8.00	1.70	5.30	0.00
49	24.80	8.70	89.10	38.40	0.00	1.30	6.80	0.00
50	22.90	8.30	78.80	47.10	0.00	2.50	4.40	0.00
51	22.30	5.20	87.00	34.70	0.00	1.80	7.30	0.00
52	21.00	4.50	87.30	34.20	0.00	3.70	8.30	0.05
01	22.90	6.60	87.30	46.80	0.00	3.10	3.30	0.40
02	21.40	7.20	86.30	43.70	0.00	3.50	4.90	0.45
03	23.10	6.00	83.00	40.20	0.00	3.80	8.00	1.15
04	19.50	10.60	85.10	53.70	13.50	4.90	3.10	0.45
05	22.50	8.60	88.30	57.00	0.00	4.70	8.60	1.25
06	21.70	10.30	91.20	57.20	10.50	4.40	5.10	0.45
07	23.50	10.20	89.20	57.80	1.70	4.70	5.40	1.15
08	25.90	13.10	85.50	50.50	0.00	5.90	5.50	1.75
09	22.10	10.60	86.50	57.00	9.10	6.20	4.90	1.15
10	27.50	12.00	78.00	40.00	0.00	5.40	9.60	2.15
11	29.70	13.20	80.10	37.00	0.00	4.10	7.90	2.35
12	32.20	15.60	70.50	38.80	0.00	6.30	10.10	2.45
13	30.90	17.20	77.20	41.20	0.40	5.10	9.90	2.65
14	36.70	16.70	69.20	34.70	0.00	5.60	10.20	2.88

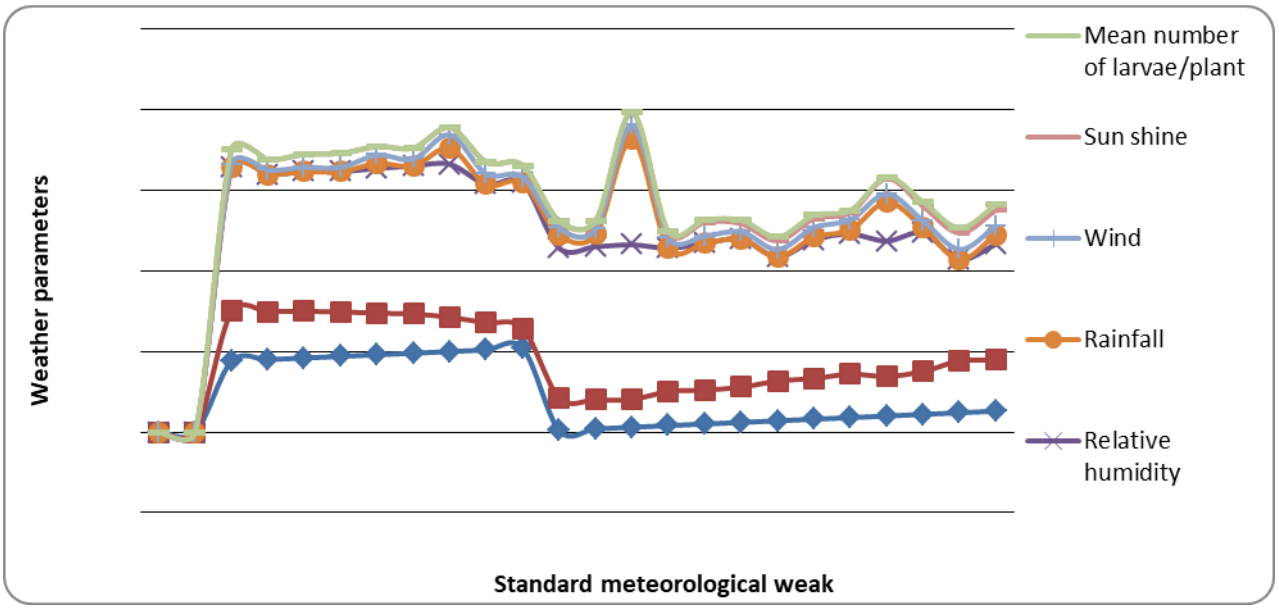


Graph 1: Larval intensity of *Helicoverpa armigera* and corresponding periodical meteorological data during 2018-19

The incidence of *H. armigera* on tomato was recorded at regular weekly interval from transplanting to harvesting of tomato crop and correlated with the corresponding meteorological data to understand the relationship between them during the season 2019-20. Initial incidence of the pest was observed on 14.01.2020, in 02nd standard meteorological week i.e., with a mean fruit infestation of 0.15. The average maximum and minimum temperature prevailed during the initial infestation were 18.10 ºC and 9.50 ºC, respectively. Maximum and minimum relative humidity was 95.00 and 67.00 per cent, respectively. The average wind speed prevailing during this week was 3.50 km/h. The sun shine was 4.50 hrs/ day during this period. The fruit damage reached to peak by March 24, 2020 with mean larval population of 3.25 during 13th standard meteorological week. The average maximum and minimum temperature prevailing during this period were 31.60 and 15.80 ºC, respectively in the 13th SMW. The average maximum and minimum relative humidity was 72.00 and 38.00, per cent, respectively and average wind speed was observed during 13th standard week was 5.10 km/hr and sunshine 10.10 hrs in a day. Relationship between larval population and major weather parameter during the crop period were also worked out through correlation coefficient by statistical analysis. The results indicated positive significant correlation association between the maximum temperature (r = 0.402*) and negative correlation association with minimum temperature i.e.- (r = -0.419*) and negative significant association with morning or maximum relative humidity (r = -0.692**) and negative association with evening or minimum relative humidity (r = -0.004**). The correlation was negative and non-significant with rain fall i.e. (r = - 0.180) and positive correlation was found to a level of wind speed (r = 0.168**) and the correlation between larval population and sun shine hrs was positively significant i.e. (r = 0.238*).

Table 2: Larval intensity of *Helicoverpa armigera* and corresponding periodical meteorological data during 2019-20

Standard meteorological week.	Temperature (0C)		Relative humidity		Rainfall	Wind speed	Sun shine	Mean no. of larvae/plant
	(Max.)	(Min.)	(Max.)	(Min.)	(mm)	(km/h)	hrs/day	
44	30.90	16.70	89.40	45.10	0.00	2.10	9.20	0.00
45	29.80	18.40	85.10	40.30	0.00	2.60	6.50	0.00
46	29.00	16.30	86.70	37.70	0.00	2.70	8.10	0.00
47	27.60	14.60	87.10	41.70	0.00	2.70	8.70	0.00
48	25.80	13.30	90.00	58.00	3.00	5.20	5.30	0.00
49	24.30	14.30	92.00	44.00	0.00	4.30	6.90	0.00
50	21.30	9.90	95.00	69.00	10.00	8.30	4.50	0.00
51	16.80	11.90	86.00	66.00	0.00	6.40	7.30	0.00
52	12.30	8.80	90.30	72.30	0.00	3.70	7.30	0.00
1	20.30	4.20	93.00	62.00	8.00	4.30	4.40	0.00
2	18.10	9.50	95.00	67.00	7.60	3.50	4.90	0.15
3	17.30	8.10	96.00	81.00	65.60	8.50	8.00	0.05
4	21.20	10.90	89.00	46.00	0.00	6.30	3.20	1.05
5	21.10	7.50	91.00	46.00	0.00	4.70	8.50	1.35
6	21.90	8.30	92.00	46.00	0.00	4.40	5.10	2.15
7	24.70	6.70	77.00	42.00	0.00	4.70	5.40	2.35
8	25.30	11.00	86.00	55.00	1.80	5.90	5.50	2.15
9	27.00	13.70	87.00	53.00	2.60	6.20	4.50	1.35
10	24.60	15.00	84.00	58.00	24.20	5.10	9.60	0.75
11	26.60	13.90	86.00	55.00	3.40	4.10	9.00	2.75
12	32.20	14.30	63.00	39.00	0.00	6.30	10.20	3.05
13	31.60	15.80	72.00	38.00	6.00	5.10	10.10	3.25



Graph 2: Larval intensity of *Helicoverpa armigera* and corresponding periodical meteorological data during 2019-20

Correlation analysis between population of tomato fruit borer and abiotic weather parameters 2018-19 and 2019-20

Weather Parameters	Correlation Value 2018-19	Correlation Value 2019-20
Temperature Max.	0.503*	0.402*
Temperature Min.	0.613**	-0.419*
Humidity Max.	-0.664**	-0.692**
Humidity Min.	-0.008	-0.004**
Rainfall mm	-0.164	-0.180
Wind km/h	0.792**	0.168**
Sun shine hrs/day	0.491*	0.238*

**Correlation is significant at the 0.01 level
*Correlation is significant at the 0.05 level

Regression analysis between population of *Helicoverpa armigera* on tomato and abiotic factors in 2018-19

Linear correlation revealed that the different all weather factors, wind speed, humidity, maximum temperature, sun shine and rainfall were found to be most regulating factors which caused 62.80, 44.10, 25.30, 24.1 and 2.6 per cent variation in *H. armigera* population respectively. Further linear regression equation observed that among various factors, humidity (y = -0.115x + 10.51) and rainfall y = (-0.040x + 0.977) were seen negative impacts on *H. armigera* population which showed that for one unit increase in humidity and rainfall there were 10.51 and 0.97 unit respectively decreased in *H. armigera* population but maximum temperature (y= 0.113x - 2.032), wind speed (y = 0.523x - 1.118) and sun shine (y = 0.225x - 0.675) were found positive impacts on *H. armigera* population which showed that one unite decrease in max temperature, humidity and sun shine there were 2.03, 1,18 and 0.67 unit increased *H. armigera* population respectively.

Regression analysis between population of *Helicoverpa armigera* on tomato and abiotic factors in 2019-20

Linear correlation revealed that the different all weather factors, humidity, maximum temperature, rainfall, wind speed and sun shine were found to be most influencing factors which caused 45.20, 13.80, 3.20, 2.10 and 0.50 per cent variation in *H. armigera* population respectively. Further linear regression equation showed that among various factors, humidity (y = -0.099x + 9.640) and rainfall (y = -0.014x + 1.049) were seen negative impacts on *H. armigera* population which showed that for one unit increase in humidity and rainfall there were 9.64 and 1.04 unit decreased in *H. armigera* population respectively but maximum temperature (y = 0.081x - 0.997), sun shine (y = 0.037x + 0.599) and wind speed (y = 0.099x + 0.481) were found positive impacts on *H. armigera* population which showed that one unit decrease in max. temperature, humidity and sun shine there were 0.99, 0.59 and 0.48 unit increased *H. armigera* population respectively during 2019-20.

Regression analysis between population of *Helicoverpa armigera* on tomato and abiotic factors in 2018-19 and 2019-20

	2018-19		2019-20	
Abiotic factors	**R^2 value**	**Linear regression equation**	**R^2 value**	**Linear regression equation**
Maximum temperature	$R^2 = 0.253$	Y= 0.113x - 2.032	$R^2 = 0.138$	y = 0.081x - 0.997
Humidity	$R^2 = 0.441$	Y = -0.115x + 10.51	$R^2 = 0.452$	y = -0.099x + 9.640
Wind speed	$R^2 = 0.628$	Y = 0.523x - 1.118	$R^2 = 0.021$	y = 0.099x + 0.481
Rainfall	$R^2 = 0.026$	Y = -0.040x + 0.977	$R^2 = 0.032$	y = -0.014x + 1.049
Sun shine	$R^2 = 0.241$	Y = 0.225x - 0.675	$R^2 = 0.005$	y = 0.037x + 0.599

Conclusion

The present study revealed that the incidence of *H. armigera* was started in 52th standard meteorological week thereafter, larval population increased gradually with increase in temperature and reached to its peak in 14th standard meteorological week (last week of March). Weather parameters, temperature (maximum and minimum), humidity maximum, wind velocity and sunshine hours had significant positive correlation with larval population.

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