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Impact of Weather Parameters on Population Dynamics of Tobacco Leaf Eating Caterpillar, *Spodoptera litura* (F.) Infesting Groundnut

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ABSTRACT

Investigations on impact of weather parameters on population dynamics of tobacco leaf eating caterpillar, *Spodoptera litura* (F.) infesting groundnut was carried out at regional research station, Anand Agricultural University, Anand during *kharif* 2021. Infestation of the *S. litura* on groundnut was observed from July to October. The infestation of *S. litura* started from third week of July (29th SMW) during *kharif* 2021. Thereafter, population and per cent damaged plants were gradually decreased toward the maturity of the crop up to last week of October (44th SMW). The maximum larval population of *S. litura* as well as per cent damaged plants were observed during the month of September (35th SMW to 39th SMW). *S. litura* larvae showed significantly positive correlation with rainfall, morning and evening relative humidity as well as morning and evening vapor pressure. Morning relative humidity contributed 44.5% variation in the larval population of *S. litura.*

Keywords Groundnut, Relative humidity, Rainfall, Seasonal incidence, *Spodoptera litura*.

INTRODUCTION

The world's fourth-most important oilseed crop, greatest source of edible oil, and thirteenth-most significant food crop is groundnut, *Arachis hypogea* Linnaeus (Ramanathan 2001). It grows on the continent as well as in tropical and subtropical climate. China, India, Nigeria, the United States, Taiwan, Indonesia, Senegal, Ghana, Argentina and Brazil are also significant producers of groundnuts (Fletcher and Shi 2016). The highest groundnut producing states in India include Gujarat, Rajasthan, Tamil Nadu, Andhra Pradesh, Bengal, Madhya Pradesh, Telangana, Maharashtra and West Bengal (Anon 2021a). Gujarat has the most groundnut growing land and production, with the lowest productivity per hectare when compared to other states like Telangana, Tamil Nadu and Rajasthan. (Kumar 2023). Gujarat has six main groundnut-growing districts: Junagadh, Rajkot, Amreli, Jamnagar, Bhavnagar and

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Kutch. These districts have 2.16 million hectares of groundnut farms with an annual production of 4.13 million tonnes and a productivity of 1911 kg/ha (Anon 2021b). Low groundnut productivity is caused by a range of biotic and abiotic causes, among them, insect pests are recognized as one of the biggest limitations on groundnut production, resulting in large losses in India (Huang *et al.* 2023). In India, only insect pests are responsible for 10–20% crop losses and 10–25% post-harvest losses of groundnut production, with long-term storage suffering the largest losses (Shahzad *et al.* 2023). Low population densities of defoliators make groundnuts sensitive to them, although mature plants can withstand severe leaf loss, especially during the monsoon season (Dodiya *et al.* 2023). Tobacco leaf-eating caterpillar, *Spodoptera litura* (F.) is a well-known leaf feeder and with a high reproduction rate, huge damage potential and the capacity to travel over great distances in the adult stage make this polyphagous pest is economically significant (Dodiya and Barad 2022). This insect has become a serious threat to the ecology of groundnuts because of changes in intensive agricultural cropping patterns (Rao and Rameshwar 2013). It ate up 54.70% of the leaf surface at the seedling stage and reduced pod production by 25.80%. It reduced productivity by 19.00% and ate 49.10% of the leaf area when in blossom. It consumed 38.80% of the leaf area at pegging, which decreased yield by 5.7% (Veeranna *et al.* 2023). *S. litura* is known as a "National pest" due to its severe consumption (Zhang *et al.* 2021) 80–100% of the damage was noted in a tobacco nursery in Gujarat (Bhatt *et al.* 2018). The insect infestation caused a 12–13% reduction in castor yields (Sujatha *et al.* 2011) whereas 33–35% of the groundnut crop suffered damage (Srinivasa *et al.* 2012). Looking to the importance of groundnuts in Gujarat's agricultural economy and the impact of *Spodoptera litura* (F.) on groundnut production, the study on "Seasonal incidence of tobacco leaf eating caterpillar, *S. litura* in relation to weather factors infesting groundnut" was carried out.

MATERIALS AND METHODS

The study on impact of weather parameters on population dynamics of tobacco leaf eating caterpillar, *S. litura* infesting groundnut was carried out at Regional Research Station, AAU campus, Anand during *kharif,* 2021. Groundnut variety Gujarat Groundnut 34 (GG 34) was sown in the plot of 10.80 × 6.00 m by adopting standard agronomical practices. The plot was kept free from insecticidal spray throughout the crop period. The plot was divided into six equal quadrates (3.6 × 3.0 m) to record the incidence of tobacco leaf eating caterpillar population. From each quadrate, ten plants were selected randomly for counting of larvae as well as damaged and healthy plants. The observations were recorded at weekly interval starting from 15 days after sowing till the harvest of the crop. Observation was `recorded from each randomly selected plant at weekly interval. Finally, average population per plant was worked out. The data on population of this pest was correlated with different meteorological parameters viz., Bright sunshine hours, maximum and minimum temperature, relative humidity (morning and evening), vapor pressure (morning and evening), rain fall and wind speed and the pearson correlation was calculated using SPSS software. The stepwise regression analysis was worked out considering the no. of larvae as dependent variable and (weather parameters) as the independent variable using SPSS software.

RESULTS AND DISCUSSION

Larval population of *S. litura* and its damage

Larval population of *S. litura* observed on groundnut crop from July to October (Table 1). The population of *S. litura* were recorded from the 3rd week of sowing to the harvest of the crop. The infestation of pest started during third week of July (29th SMW) and remained until 5th week of October (44th SMW). Initially, its population was low (0.17 larva/plant), which was gradually increased in its numbers and attained peak level (2.50 larvae/plant) during the 3rd week of September (37th SMW). Thereafter, larval population steadily decreased from the 40th (1.33 larvae/plant) to the 44th (0.33 larva/plant) SMW. During the 35th to the 39th SMW, *S. litura* larvae were found to be most active with maximum larval population. The activity of *S. litura* also reflected on plant damage. The damage to groundnut crops increased as the larval population increased. At initial stage of pest, 7.0% of the plant damage was recorded which increased

Table 1. Population dynamics of tobacco leaf eating caterpillar, *S. litura* in relation to different weather parameters (*kharif* 2021) (n=16).

Month	Week	SMW	No. of larva (e)/ plant	Dam- aged plant(%)	BSS (hr/day)	RF (mm)	WS (km/hr)	Tempera- ture (°C) Max.	Min.	Relative humidity (%) RH1	RH2	Vapor pressure (mm of hg) VP1	VP2	EP (mm)
July	III	29	0.17	7.00	3.5	10.4	5.7	33.9	27.1	89	71	24.6	24.3	3.5
	IV	30	0.50	9.00	0.4	93.0	6.5	31.0	26.4	90	81	23.8	24.4	2.9
August	I	31	1.00	15.00	0.3	5.6	8.4	30.5	26.3	87	74	22.4	23.2	2.8
	II	32	1.17	25.33	3.7	0.0	5.8	33.0	26.6	84	60	22.6	21.4	4.6
	III	33	1.33	60.67	6.1	5.6	5.5	33.5	26.1	87	64	22.9	21.9	5.2
	IV	34	1.67	65.33	1.7	1.0	4.6	31.2	26.0	90	69	23.3	22.7	2.5
September	I	35	2.00	72.67	4.2	82.8	4.6	33.2	25.6	92	75	23.3	24.5	4.1
	II	36	2.17	80.67	4.3	13.4	4.7	32.7	26.3	91	78	23.9	24.6	2.6
	III	37	2.50	90.33	2.0	54.5	4.2	30.3	25.8	94	84	23.8	25.1	2.6
	IV	38	2.33	76.67	0.6	89.2	4.2	29.8	25.7	95	85	24.0	24.8	1.8
	V	39	2.00	74.33	3.1	72.0	4.1	31.7	25.5	94	72	23.8	23.9	3.5
October	I	40	1.33	71.66	6.6	18.0	2.8	33.6	25.9	92	63	23.8	23.9	3.3
	II	41	1.00	68.67	6.6	0.4	2.5	35.0	25.8	91	58	23.5	23.0	3.1
	III	42	0.67	65.33	8.3	0.0	3.0	34.7	21.6	83	38	17.7	14.9	4.2
	IV	43	0.50	62.33	9.3	0.0	2.5	33.1	21.2	83	41	17.2	14.4	3.3
	V	44	0.33	58.00	9.7	0.0	2.9	33.1	16.7	73	23	11.8	9.3	3.7

SMW : Standard meteorological week
BSS : Bright sunshine hours
RF : Rainfall
WS : Wind speed
MAX T : Maximum temperature
MIN T : Minimum temperature
RH1 : Morning relative humidity
RH2 : Evening relative humidity
VP1 : Morning vapor pressure
VP2 : Evening vapor pressure
EP : Evaporation

gradually started in the 3rd week of July (29th SMW) and reached peaked at 90.33% in the 3rd week of September (37th SMW). The maximum damage of *S. litura* was found during the 35th to 39th SMW and caused up to 90.33% damage. Thereafter decrease the damage of *S. litura* from 40th SMW to 44th SMW and ranged between 71.66 to 58.00%.

Table 2. Correlation coefficient (r) of weather parameters with larval population of *S. litura* in groundnut (*kharif* 2021) (n=16). *Significant at 0.05% level of significant.

Weather parameters	Correlation co-efficient (r) No. of larva (e)/plant
Bright sunshine hours (BSS), hrs/day	-0.443*
Rainfall (RF), mm	0.474*
Wind speed (WS), km/h	-0.016
Maximum temperature (Max T), °C	-0.490*
Minimum temperature (Min T), °C	0.417
Morning relative humidity (RH1), %	0.694*
Evening relative humidity (RH2), %	0.634*
Morning vapor pressure (VP1), mm of hg	0.512*
Evening vapor pressure (VP2), mm of hg	0.576*
Evaporation (EP), mm	-0.343

Correlation coefficient between *S. litura* and weather parameters

In nature, organism populations are never fully steady. Weather factors affects the development and fluctuation of population density. The correlation coefficient analysis (Table 2) revealed that the rainfall, morning and evening relative humidity as well as morning and evening vapor pressure were significantly ($p<0.05$) positive correlated with larval population of *S. litura* (r = 0.474*, r = 0.694*, r = 0.634*, r = 0.512* and r = 0.576*, respectively). *S. litura* population also had positive correlation with minimum temperature (r = 0.417) but results were found non-significant. While, bright sunshine hours and maximum temperature

Table 3. Regression - model summary between morning relative humidity and larval population of *S. litura*. Note: "a" is predictor: Constant, RH1.

Model	R	R^2	Adjusted R^2	Std error of the estimate
1	0.694[a]	0.482	0.445	0.560

Table 4. Regression – ANOVA. Note : "a" is dependent variable, "b" is predictor : Constant, RH1.

Model [a]	Sum of squares	df	Mean square	F	Sig
1 Regression	4.081	1	4.081	13.010	0.003[b]
Residual	4.391	14	0.314	-	-
Total	8.472	15	-	-	-

were significantly negative correlated with *S. litura* population (r = -0.443* and r = -0.490*, respectively). Wind speed and evaporation were negatively correlated with *S. litura* population (r = -0.016 and r = -0.343, respectively) but results were found non-significant.

Regression analysis between *S. litura* and weather parameters

Regression analysis reveals the functional relationship between the dependent (larval population) and independent variable (weather parameters). Here, stepwise regression approach was used to build a regression model describing the variation in larval population of *S. litura*. All the weather parameters exhibiting significant ($p<0.05$) association with the larval population was included to build the prediction model. Stepwise regression analysis generated one model (Table 3) by entering only one variable morning relative humidity (RH1), defining 44.5% (Adjusted R^2 =0.445) of the changes in the larval population of *S. litura* along with total correlation of (0.694). RH1 variable was entered and another variable have been excluded in this model, indicating it's direct impact on larval population of *S. litura.* Regression analysis of variance (ANOVA) revealed significant ($p< 0.05$) mean sum of square pertaining to the independent variable (RH1) suggesting functional relationship between the morning relative humidity and larval population of *S. litura* (Table 4).

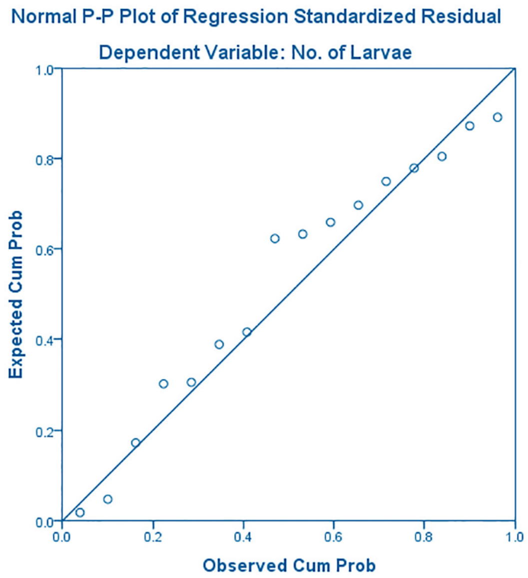

Fig. 1. Normal probability plot of the residuals is a scatter plot with the observed no. of larvae on the x axis and the expected no. of larvae on the y axis.

The regression coefficient of predictor RH1 (0.093) is found significant ($p<0.05$) along with constant value of -6.949, hence we can use this model to predict the larval population (Table 5) based on value of independent variable (Morning relative humidity). Thus, regression model $Y = a + bx$ would be as $Y = (-6.949) + 0.093\ (X)$, where, Y is dependent variable (larval population), a is constant, b is the regression coefficient of RH1 and X is value of independent variable (RH1). Based on the above prediction model the Probability-Probability (P-P) plot, a scatter plot of the observed cumulative probability of larvae against the expected cumulative probability of larvae of the corresponding order statistics from a normal distribution (Fig. 1) is drawn. The data are approximately normally distributed, the points in a normal

Table 5. Regression – coefficients between morning relative humidity and larval population of *S. litura*. Note: "a" is dependent variable.

Model [a]	Unstandardized coefficients B	Unstandardized coefficients Std error	Standardized coefficients Beta	t	Sig	95.0% confidence interval for B Lower bound	95.0% confidence interval for B Upper bound
1 (Constant)	-6.949	2.289	-	-3.036	0.009	-11.859	-2.040
RH1	0.093	0.026	0.694	3.607	0.003	0.038	0.149

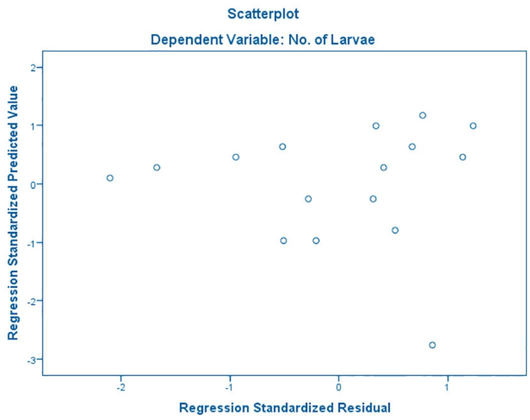

Fig. 2. Scatterplot of regression standardized residual against regression standardized predicted value.

probability plot lie approximately on a straight line. It means this model fit for normal distribution of regression standardized residual of dependent variable (larval population). The scatterplot of regression standardized residual against regression standardized predicted value depicted (Fig. 2) the residual is independently distributed and not following any patterns.

Larvae as well as damage of *S. litura* noted during the third week of July (29th SMW) to the fifth week of October (44th SMW). Maximum larval population and damage per cent observed during the 35th SMW to 44th SMW. Rainfall, morning and evening relative humidity and morning and evening vapor pressure were significantly positive correlation with larval population of *S. litura*. Morning relative humidity alone explained 44.5% of the change in larval population of *S. litura*. Gedia (2005) concluded that activity of *S. litura* started from mid-July (28th to 30th standard week) while it was observed till mid-October (43rd standard week) on groundnut. Mishra *et al.* (2021) revealed that the *S. litura* initially arrived on groundnut in the first week of August (32nd SMW), with a peak of 1.67 larvae/mrl in the second week of September, (37th SMW). Wankhede *et al.* (2020) reported that the population of *S. litura* on groundnut had significant and positive correlation with evening relative humidity whereas maximum temperature showed negative correlation but non-significant. While, wind speed showed non-significant negative relationship with *S. litura* population. Senthilkumar *et al.* (2019) revealed that the relative humidity had significant positive correlation, while wind speed and maximum temperature had negative correlation and minimum temperature had positive correlation with mean larvae of *S. litura* on groundnut during *kharif* season. Thus, present findings are in agreement with the earlier reports.

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