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Population Dynamics of Major Insect Pests of Castor, *Ricinus communis* L. as Influenced by Weather Variables in South-west Haryana

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***Abstract*:** The population dynamics of major insect pests of castor was studied during 2018-19 at CCSHAU RRS, Bawal on castor hybrid DCH 177. Among the major insect pests, castor semilooper, *Achaea janata* was the first to infest the crop reaching its peak population of 6 larvae per plant in 35th SMW. The peak population of *Spodoptera litura* was 3.4 larvae/plant during 41st SMW. Peak nymphal population of leafhopper was in 44th SMW. Maximum capsule damage by castor shoot and capsule borer, *Conogethes punctiferalis* was during 50th SMW of 2018. The rainfall (r= 0.688) and relative humidity were positively (r= 0.836) related with *A. janata* larval population. Maximum temperature (r= 0.900) and bright sunshine hours (r= 0.737) exhibited a positively significant correlation with the larval population of *S. litura*. Leafhopper nymphal population and capsule damage by *C. punctiferalis* were negatively influenced by evening relative humidity (r= -0.775) and rainfall (r= -0.505) and maximum (r= -0.698) and minimum temperature (r= -0.828), respectively. Regression analysis revealed that the weather variables exhibited a significant effect on the population dynamics of the pests with adjusted coefficients of determination to the tune of 0.67, 0.90, 0.58 and 0.67 for *A. janata*, *S. litura*, *E. flavescens* and *C. punctiferalis*, respectively.

***Keywords*:** Castor, DCH 177, *Achaea janata*, *Spodoptera litura*, *Empoasca flavescens*, *Conogethes punctiferalis*

In India, major oilseed crops of *kharif* season are soybean, groundnut, sesamum and castor. Castor (*Ricinus communis* L.) is a non-edible oilseed crop which belongs to the family Euphorbiaceae. Main use of castor crop is to extract non-edible oil from its seeds. Well drained sandy loam soils are suitable for its cultivation. In India, castor was cultivated on 1.05 million ha area producing about 1.84 million tonnes during 2019-20 with a productivity of 1.76 tonnes/ha (Anonymous 2022). It plays vital role in Indian economy and fetched Rs. 6802 crores in terms of valuable foreign exchange by exports of about 0.73 million tonnes of castor oil during 2020-21 (APEDA 2022). There are many constraints in the cultivation of castor but insect pests are of prime importance especially in the rainfed areas. More than 107 species of insects and six species of mites are recorded on castor at different stages of crop growth (Lakshminarayana and Raoof 2005) and most of the insect pests infesting castor crop are either defoliators or sucking pests (Sarma et al 2005). The economically important insect-pest species associated with castor in south-west Haryana are castor shoot and capsule borer (*Conogethes punctiferalis*), castor semilooper (*Achaea janata*), leafhopper (*Empoasca flavescens*), castor hairy caterpillar (*Euproctis lunata*) and tobacco caterpillar (Gaur 2014, Puneet et al 2020, Ranga et al 2021). Various insect pests account for 17.2-63.3 per cent seed yield losses in castor (Lakshminarayana and Duraimurugan 2014). Insects are poikilothermic organisms and are largely influenced by the ambient conditions as far as their growth, development, life cycle, population dynamics and other life history traits are concerned. The various weather variables are known to cause variability in population dynamics of castor major insect pests to the tune of 74.2- 97.5 per cent (Manjunatha et al 2019). Studies on incidence of insect pests in relation to weather parameters give better understanding of plant insect relationship, especially in recognizing the time of economic management.

MATERIAL AND METHODS

The present investigations were carried out in field experiment during 2018-19 at CCS Haryana Agricultural University Regional Research Station, Bawal located at latitudes 28°10' N, longitudes 76° 50' E and 266 m above mean sea level (Rao et al 2005). The area of 250 m^2 (r hybrid DCH 177) was sown during 2nd fortnight of July, 2018 as per recommendations of package of practices of *Kharif* crops by CCS HAU, Hisar (Anonymous 2018). The experiment area was not sprayed with any insecticide.

Observations recorded: Thirty plants in each experimental plot were randomly selected and tagged for recording observations for incidence of major insect pests of castor *viz*., castor semilooper, *Achaea janata*; tobacco caterpillar, *Spodoptera litura*; leafhopper, *Empoasca flavescens* and castor shoot and capsule borer, *Conogethes punctiferalis*. Infestation levels of castor semilooper and tobacco caterpillar were recorded by counting the number of larvae per plant. The nymphal population of leafhopper was recorded from 3 leaves from randomly selected thirty plants starting from germination at weekly intervals. The leaves were selected on the main shoot - one from top (excluding two top-most leaves), middle (medium matured leaves) and bottom (leaving two bottom-most leaves). The incidence of castor shoot and capsule borer was observed by calculating the number of infested capsules as compared to total number of capsules from 3 branches per plant at weekly intervals.

Weather data: Meteorological data on various weather parameters like temperature (maximum and minimum), relative humidity (morning and evening), wind velocity, evaporation, rainfall and bright sunshine hours was collected from the Meteorological observatory, RRS, Bawal.

Statistical analysis: All the observations recorded in the due course of investigations were subjected to statistical analysis by using SPSSv23 (IBM Corp 2015). Karl Pearson coefficient was calculated to elucidate the impact of weather variables on population dynamics and fluctuations of insect pests. Graphs and correlograms were prepared using OriginPro® (2022). Correlation analysis was conducted with weather data of lag weeks also as the previous weather conditions ultimately determines the current pest population. Step-wise linear regression models were formulated to quantify the impact of weather variables on insect pests.

RESULTS AND DISCUSSIONS

The mean larval populations of *A. janata* and *S. litura* are presented in Table 1 along with respective SMW and weather data. Similarly, mean nymphal population and mean per cent capsule damage is tabulated as Table 2.

Castor semilooper, *Achaea janata* Linn.: The castor semilooper (*A. janata*) first appeared during 32nd standard meteorological week (SMW) with an average larval population of 3.5 per plant. It started increasing and reached to a peak population of 6 larvae per plant during 35th SMW (Fig. 1). The larval population reduced to 1.2 larvae per plant during 41st SMW (second week of October). The larval population of castor semilooper was active from 30th SMW to 47th SMW (Singh et al 2016b) and *A. janata* larval population from 28th to 44th SMW on castor hybrid DCH 177 (Ranga et al 2021).

During current week, rainfall (r= 0.688) and evening R.H. (r= 0.836) were positively and significantly correlated with *A. janata* larval population, whereas maximum temperature (r= -0.799) and evaporation (r= -0.836) exhibited a negatively significant (Fig. 2). During lag week I and II both, minimum temperature negatively influenced the larval population. During lag week I, the evening R.H. (r= -0.757), minimum temperature (r= 0.620) and maximum temperature (r= -0.677) were major influencers of larval populations of *A. janata*. Umbarkar and Patel (2016) who reported that *A. janata* had negative correlation with maximum temperature. The results are also in agreement with Singh et al (2016a) where evening relative humidity had positive significant correlation with larval population of *A. janata*. Rainfall was

Table 1. Mean larval populations of *S. litura* and *A. janata* on castor hybrid DCH 177 during *kharif*, 2018

SMW	Temperature (ºC)		Relative humidity (%)		Wind velocity (km/hr)	Sun shine (hrs)	Evaporation (mm)	Rainfall (mm)	Mean larval population per plant*	
	Maximum	Minimum	Morning	Evening					*S. litura*	*A. janata*
31	34.9	24.2	72	51	6.1	3.6	6.6	0	-	-
32	33.5	25.9	88	60	3.8	3.3	3.2	11.9	-	3.5
33	34.9	26.4	83	54	3.6	6	5	1.5	-	1.2
34	33.7	25.8	86	60	5.4	4.3	4.4	6	-	2.2
35	30.9	24.9	91	76	3.9	2.2	3	134.5	1.2	6.0
36	30	24.4	93	76	4.2	2.1	2.6	41.2	1.2	5.2
37	32.5	23.5	87	62	4.4	7.2	3.6	3.4	1.6	4.8
38	32.4	22.7	88	59	5.9	6.5	4.9	20	1.9	3.2
39	32.2	21.1	94	57	3.7	8.3	3.5	60.3	2.1	3
40	35.4	20.1	83	39	2.8	8.8	4.7	0	3.3	2.2
41	38.6	16.7	89	36	2.1	7.2	4.1	0	3.4	1.2
42	33.8	15.8	83	34	1.9	7.4	4.3	0	2.8	-
43	32.2	13.6	82	31	1.6	6.8	3.7	0	2.4	-
44	31.4	14.2	92	38	1.8	6.2	3.1	0	1.8	-

*Each larval population is the mean of 30 observations reported to be positively correlated with larval population of *A. janata* (Manjunatha et al 2019, Ranga et al 2021). Linear step-wise regression models of *A. janata* larval population with weather parameters are presented. Among the various weather variables, maximum temperature was significant and accounted for 67 per cent variability in the population (Table 3). Manjunatha et al (2019) reported 95.2 per cent variation in semilooper larval population on castor due to weather conditions

Tobacco caterpillar, *Spodoptera litura* Fabricius : The larval population of *S. litura* was first observed during 35th SMW with population of 1.2 larvae per plant and started increasing gradually and reached to a peak population of 3.4 larvae per plant during 41st SMW (Fig. 3). The population started to decrease and reached up to 1.8 larvae per plant during 44th SMW. More or less similar appearance pattern of this pest was observed by Duraimurugan (2018) where the peak incidence was during 33rd to 43rd SMW with a gradual decline in population till 44th SMW. Ranga et al (2021) observed *S. litura* to be active from 37th to 46th SMW. . During current study, bright sunshine hours (BSS) (r= 0.737), maximum temperature (r= 0.900) and evaporation (r= 0.695) positively influenced *S. litura* larval population (Fig. 4). BSS (r= 0.610) was positively and significantly correlated with larval population of *S. litura* during Lag week I. Kanani (2013) stated that evening relative humidity was highly negatively significant correlation with leaf damage. Ahir et al (2017) recorded negative and non-significant correlation of *S. litura*

Table 2. Mean incidence of *E. flavescens* and *C. punctiferalis* on castor during *kharif,* 2018

SMW	Temperature (ºC)		Relative humidity (%)		Wind velocity (km/hr)	Sun Shine (hrs)	Evaporation (mm)	Rainfall (mm)	Leafhopper nymphs/3 leaves Per plant*	Per cent larval infestation of *C. Punctiferalis**
	Maximum	Minimum	Morning	Evening						
37	32.5	23.5	87	62	4.4	7.2	3.6	3.4	5.6	-
38	32.4	22.7	88	59	5.9	6.5	4.9	20	2.4	-
39	32.2	21.1	94	57	3.7	8.3	3.5	60.3	2.2	-
40	35.4	20.1	83	39	2.8	8.8	4.7	-	7.6	-
41	38.6	16.7	89	36	2.1	7.2	4.1	-	12.4	-
42	33.8	15.8	83	34	1.9	7.4	4.3	-	13.2	3.20
43	32.2	13.6	82	31	1.6	6.8	3.7	-	13.8	4.20
44	31.4	14.2	92	38	1.8	6.2	3.1	-	16.2	5.20
45	28.3	9.3	82	33	2.6	6	2.9	-	14.2	5.80
46	28	12.5	92	47	3.4	6.2	2.7	-	14.4	5.90
47	27.4	10.7	84	29	2.8	7	3	-	13.8	6.20
48	26.1	9	86	34	1.8	6.4	2	-	13.2	6.80
49	24.3	6.7	91	35	1	6.4	1.7	-	12.6	7.40
50	20.6	7	93	45	2.7	4.8	1.2	1	9.5	12.20
51	20.5	2.5	93	32	1.5	6.6	1.6	-	9.2	12.00
52	20.2	2.3	91	35	2	6.8	1.6	-	9	11.80
1	19.6	5	91	52	2.8	4	2.8	1.5	6.8	11.20
2	19.7	5.2	92	38	3.3	5.3	1.8	-	7.6	11.40
3	21.2	4.8	90	41	2.1	5	1.6	-	6.2	8.80
4	16.6	7.5	93	59	3.8	5.1	1.6	11	5.8	9.40
5	18.4	5.6	89	52	3	4.4	1.9	-	6	7.80
6	20.4	7.2	94	52	3.2	5.3	1.7	10.6	4.8	6.40
7	20.8	9.5	94	58	3.7	4.3	1.6	1.7	4.4	6.20
8	23.1	10.5	88	49	3.5	5.4	2.5	0.7	3.2	5.80
9	20.2	8.8	88	55	3.1	4.2	1.6	1		5.60
10	25.7	9	83	29	3.4	7.6	3.5	0.4		4.80
11	25.2	9.9	87	33	3.1	5.5	3.3	-		3.40

*****Mean of 30 observations

with temperature and negatively significant with relative humidity. Dry and hot weather was reported to favor *S. litura* larval population (Akashe et al 2015). Ranga et al (2021) revealed a positive correlation of *S. litura* larval population with temperature (maximum and minimum), evening relative humidity, wind velocity, bright sunshine hours and evaporation. Maximum temperature and evening relative humidity together caused 90 per cent variability in *S. litura* larval population. Maximum temperature alone accounted for 79 per cent variability. Manjunatha et al (2019) observed 95.6 per cent variability by weather parameters.

Leafhopper, *Empoasca flavescens* Fabricius: The population of leafhopper was first observed during 37th SMW with 5.6 nymphs per 3 leaves per plant. The peak population of leafhopper 16.2 nymphs per 3 leaves per plant was observed during 44th SMW (Fig. 5). Similar appearance of

Table 3. Step-wise linear regression models for weather parameters influencing the incidence of major insect pests of castor (2018-19)

Insect pest	Equation	Adjusted R^2
Achaea janata	$Y = -0.56\ T_{max} + 22.07$	0.67
Spodoptera litura	$Y = 0.21\ T_{max} - 0.20\ RH_e - 3.67$	0.90
	$Y = 0.29\ T_{max} - 7.29$	0.79
Empoasca flavescens	$Y = -0.32\ RH_e + 22.69$	0.58
Conogethes punctiferalis	$Y = -0.66\ T_{min} + 12.94$	0.67

Y= incidence of corresponding insect pest, T_{max}- maximum temperature, T_{min}- minimum temperature, RH_e- evening relative humidity, R^2- coefficient of determination

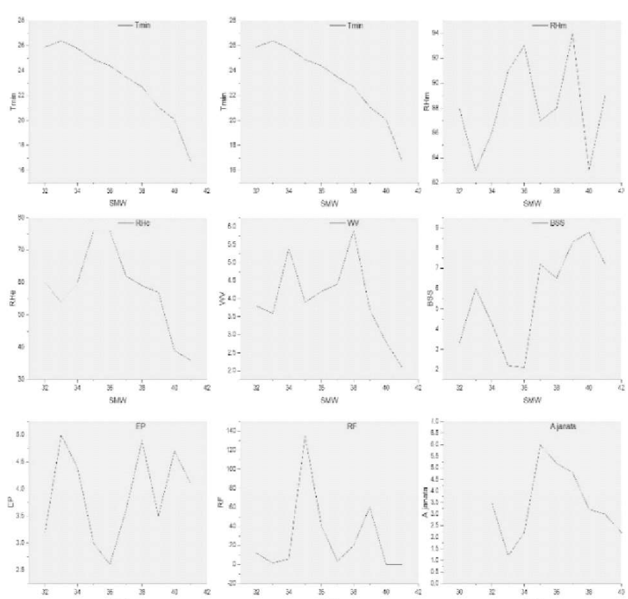
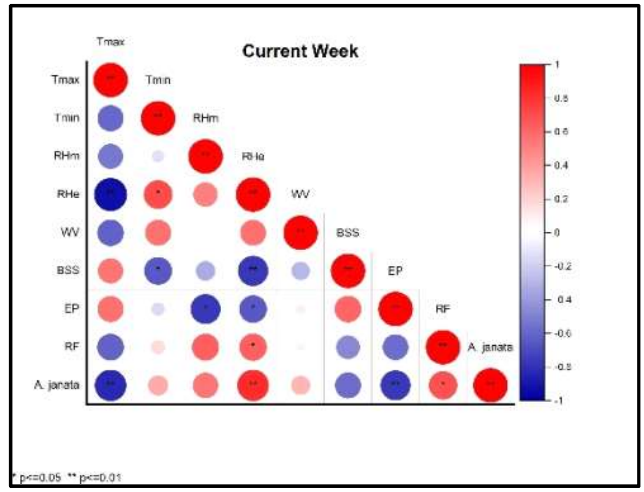


Fig. 1. *A. janata* larval population on castor in relation to weather parameters during 2018



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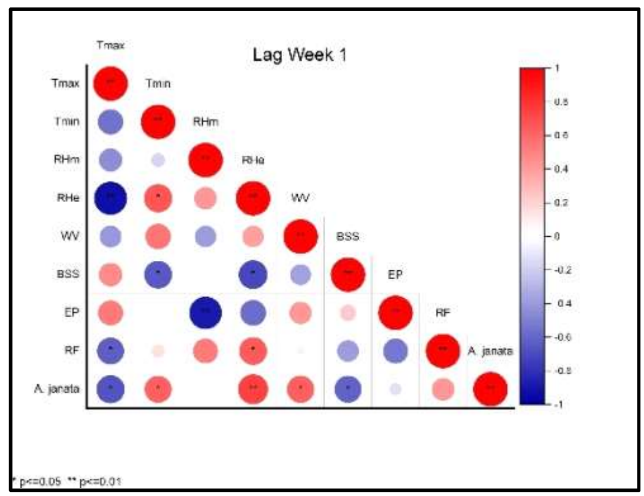

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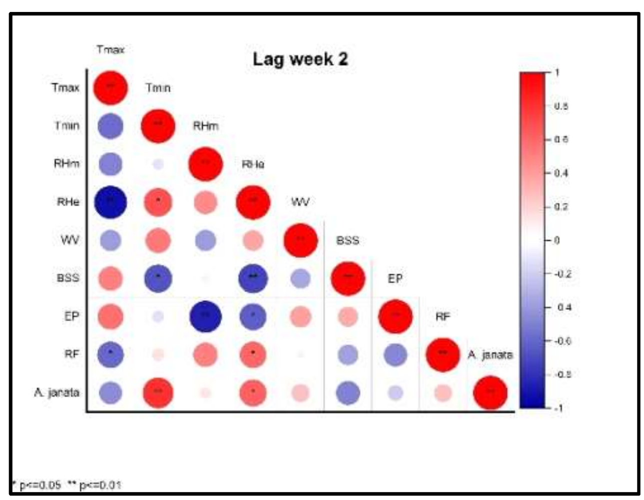

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Fig. 2. Correlograms with coefficients of correlation (r) between weather variables and larval population of *A. janata* on castor during 2018-19 for (a) Current week (b) Lag week 1 (c) Lag week 2

pest was observed by Patel et al (2015). Leafhopper population was recorded from mid-September to mid-February by Ranga et al (2021).

Correlation with weather variables: The evening R.H. (r= -0775), wind velocity (r= -0.677) and rainfall (r= -0.505) significantly influenced the leafhopper nymphal population Figure 6. During lag week I, maximum temperature (r= 0.455), morning R.H. (r= -0.473), evening R.H. (r= -0.687) and wind velocity (r= -0.423) exhibited significant effects on nymphal population. All the weather variables except minimum temperature (r= 0.128) and rainfall (r= -0.142) were reported to exert significant effects on *E. flavescens* nymphal population during lag week II.

Mounica et al (2018) observed negative correlation of leafhopper nymphal population with rainfall, maximum temperature, minimum temperature, number of rainy days and evaporation while sunshine hours and relative humidity were found to be positively correlated. Anjani et al (2018) observed high and significant correlation with all the abiotic factors *viz*. maximum temperature, minimum temperature, evening relative humidity, morning relative humidity and rainfall. Relative humidity was correlated in a negatively significant manner with leafhopper nymphal population by Ranga et al (2021).

Minimum temperature caused significant variability in leafhopper nymphal population (58 per cent) (Table 3). Ranga et al (2021) observed that evening relative humidity and maximum temperature account for 40 to 69 per cent variability in leafhopper nymphal population. Variability to the tune of 74.2 per cent in leafhopper population on castor was recorded by Mounica et al (2018). Narayanamma et al (2017) reported 33 to 52 per cent variability due to weather variables.

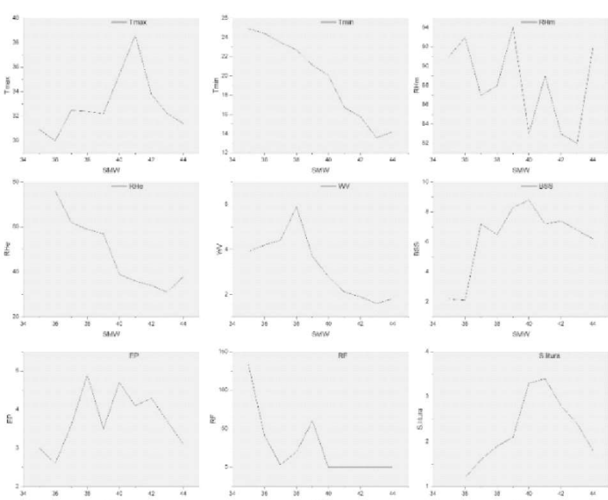
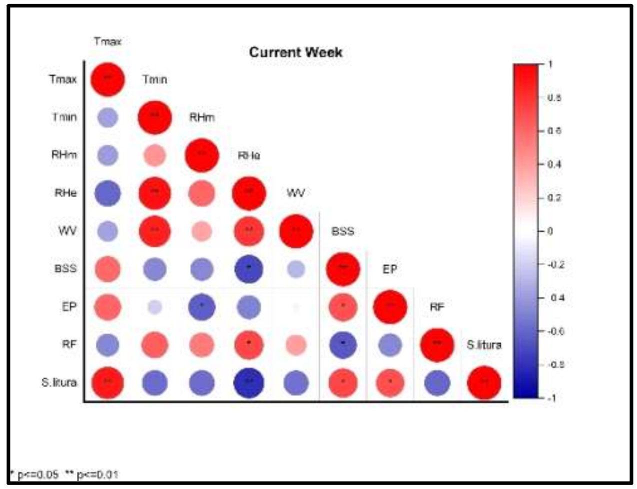


Fig. 3. *S. litura* larval population on castor in relation to weather parameters during 2018



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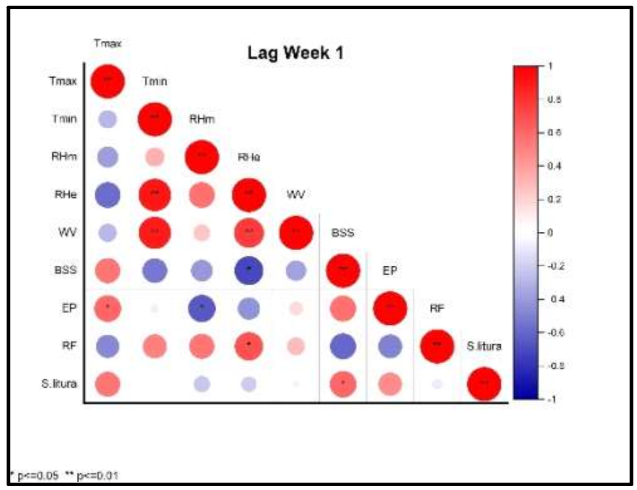

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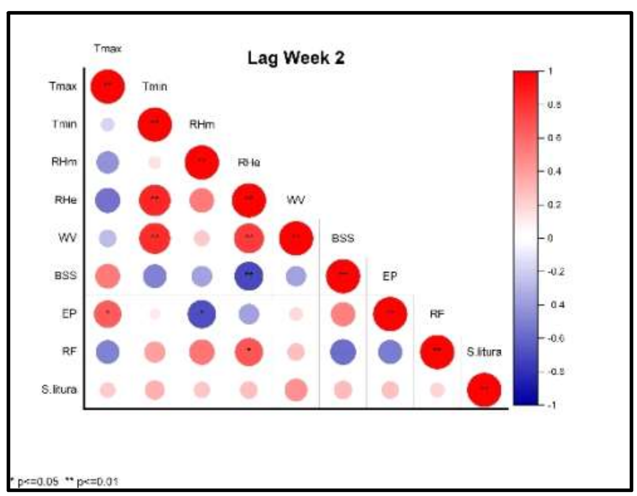

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Fig. 4. Correlograms with coefficients of correlation (r) between weather variables and larval population of *S. litura* on castor during 2018-19 for (a) Current week (b) Lag week 1 (c) Lag week 2

Castor shoot and capsule borer, *Conogethes punctiferalis* Guenée: The infestation of castor capsule borer, *C. punctiferalis* was first observed during 42nd SMW with 3.20 per cent capsule damage. Capsule damage increased gradually and reached to a peak level of 12.20 per cent during 50th SMW (Fig. 7). The incidence of *C. punctiferalis* started decreasing after 50th SMW of 2018 and reduced to 3.40 per cent by 11th SMW of 2019 (Table 2). Similarly, Akashe et al (2015) reported that the castor capsule borer remains active during October to January. Minimum temperature and evaporation exhibited highly negative and significant correlation with capsule damage during current, lag I and lag II weeks Figure 8. Maximum temperature (r= -0.698, -0.504) and morning R.H. (r= 0.603, r= 0.496)

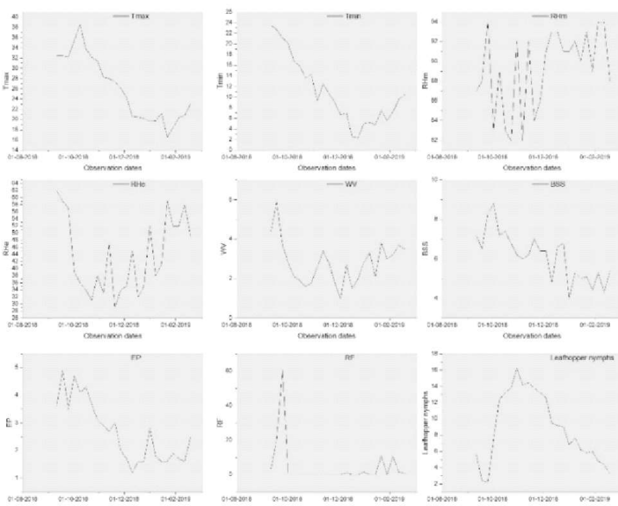


Fig. 5. Nymphal population of *E. flavescens* on castor in relation to weather parameters during 2018-19

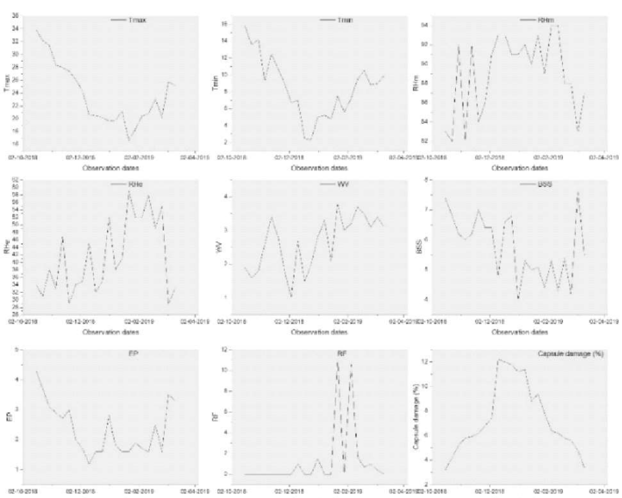


Fig. 7. Per cent capsule damage by *C. punctiferalis*on castor in relation to weather parameters during 2018-19

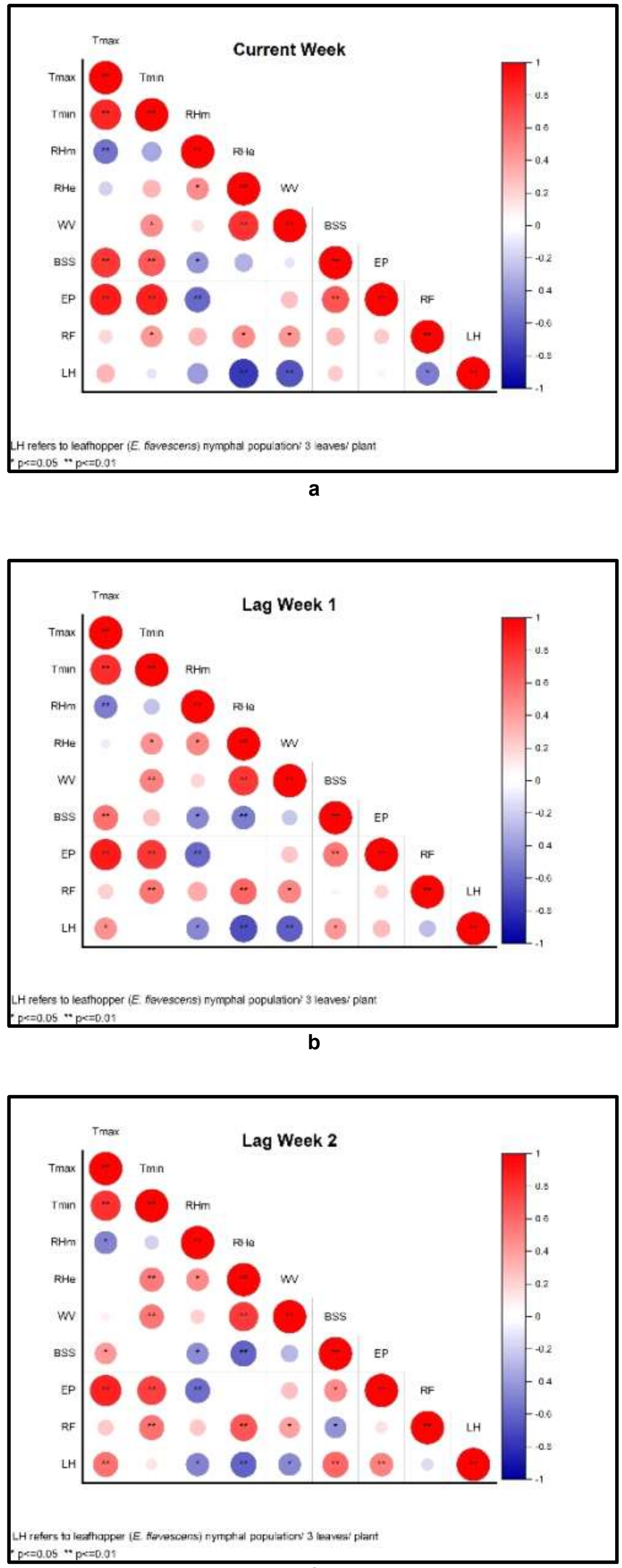
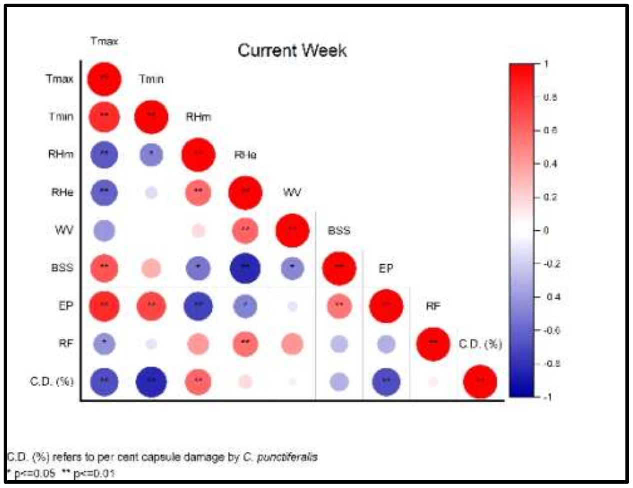


Fig. 6. Correlograms with coefficients of correlation (r) between weather variables and nymphal population of *E. flavescens* on castor during 2018-19 for (a) Current week (b) Lag week 1 (c) Lag week 2



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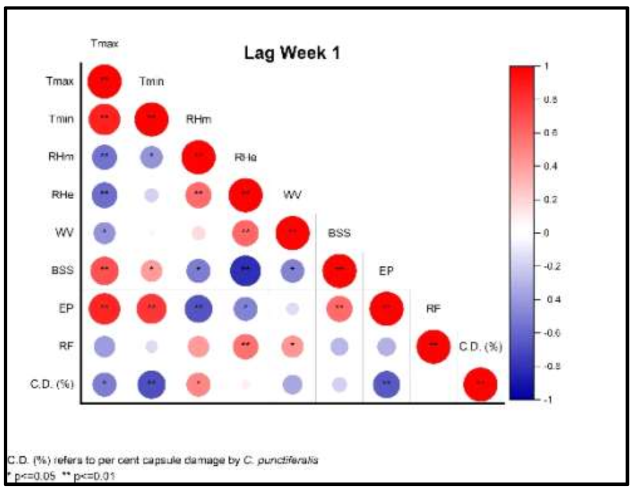

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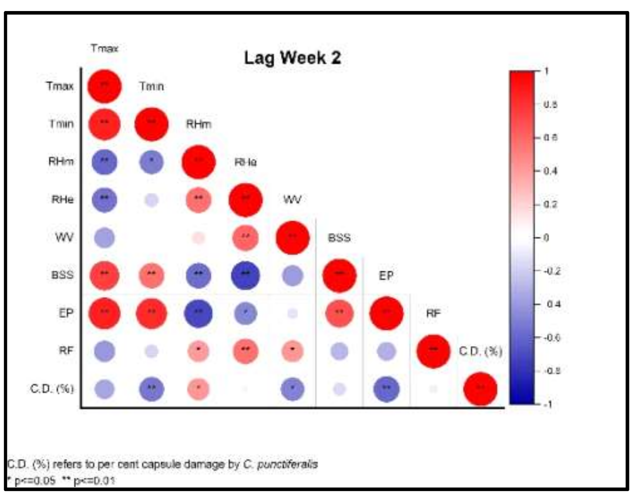

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Fig. 8. Correlograms with coefficients of correlation (r) between weather variables and capsule damage (%) by *C. punctiferalis* on castor during 2018-19 for (a) Current week (b) Lag week 1 (c) Lag week 2

significantly influenced capsule damage during both current and lag I week. Goel and Kumar (1990) who stated that minimum and maximum temperature were positively and significantly correlated with infestation of *C. punctiferalis* (=*D. punctiferalis*). A negative correlation of weather variables with capsule damage was reported with maximum temperature, minimum temperature and rainfall (Shivakumar 2016, Manjunatha et al 2019, Ranga et al 2021).Minimum temperature accounted for 67 per cent variability in capsule damage (Table 3). Weather variables accounted for 97.5 per cent variability in capsule damage by *C. punctiferalis* (Manjunatha et al 2019). Ranga et al (2021) reported weather variables causing 45 to 96 per cent variability in capsule damage by *C. punctiferalis*.

CONCLUSION

Castor semilooper was first observed during second week of August and continued to infest castor crop up to mid of October. The incidence of *S. litura* started during first week of September and continued up to first week of November and reached to a peak during second week of October. The infestation of *C. punctiferalis* initiated from third week of October and lasted till second week of March with peak capsule infestation during second week of December. The attack of *E. flavescens* started from second week of October and continued to third week of February with a peak population during first week of November. The abiotic factors i.e., weather variables undoubtedly exhibited significant effects on population dynamics of the insect pests of castor under consideration as reflected by correlation and regression analysis.

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