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Effect of weather parameters on the seasonal dynamics of tobacco caterpillar, *Spodoptera litura* (Lepidoptera: Noctuidae) in castor in Telangana State

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ABSTRACT

Field experiments were carried out for four years (2012-13 to 2015-16) to study the seasonal dynamics of tobacco caterpillar, *Spodoptera litura* in castor and its relationship with different weather parameters during *kharif* season in Telangana State. Moth catches of *S. litura* were observed throughout the crop season, wherein maximum catches (44.8 to 124 moths/trap/week) were observed during mid-August to late-October [33rd to 43rd Standard Meteorological Week (SMW)]. Peak oviposition (2.0 to 14.8 egg-masses/5 plants) and larval incidence (14.4 to 48 larvae/5 plants) of *S. litura*was recorded during mid-August to mid-November (33rd to 46th SMW) coinciding with the vegetative to primary spike development stage of the crop. The correlation analysis indicated that the moth catches and larval population of *S. litura* showed significant positive correlation with weather parameters *viz.,* maximum temperature, minimum temperature, rainfall and rainy days, while egg-masses of *S. litura* showed significant negative correlation with morning relative humidity and minimum temperature.The stepwise regression analysis revealed that minimum temperature, rainy days, wind speed and evening relative humidity could explain 64 per cent variation in *S. litura* moth catches. Among all the variables morning relative humidity was found to contribute significantly and showed 59 per cent effect on the population fluctuation of egg-masses, while rainy days and maximum temperature could explain 51 per cent variation in larval population of *S. litura* in castor.The models were validated with independent data 2015-16. The overall results suggested that the models can be used for predicting the population of *S. litura* in castor for optimizing management strategies.

Key words: Spodoptera litura, castor, seasonal dynamics, correlation, weather parameters

Castor (*Ricinus communis* L.) is an industrially important non-edible oilseed crop in India.Its seed oil has vast and varied industrial applications such as lubricants, paints, cosmetics, medicines, plasticizers etc. India meets more than 70 per cent of world requirement of castor oil and its derivatives and earns more than Rs. 5000 crores annually through exports. The current castor production in the country is 1.55 million tonnes from 0.86 million hectares with a productivity of 1803 kg ha^{-1}(DoAC & FW, 2017). One of the major constraints that limit castor productivity is the excessive damage caused by lepidopteran pests and the magnitude of the problem is quite high in Southern India resulting in lower seed yields. The tobacco caterpillar, *Spodoptera litura* (F.) (Lepidoptera: Noctuidae) is considered the most destructive lepidopter and efoliator of castor. During heavy infestation or epidemics, the larvae also attack capsules and bore into the stems causing withering of branches and partial or total death of plant (Lakshminarayana and Raoof, 2005). *S. litura* is polyphagous in habit, feeds on variety of host plants and survives throughout the year in a given agro-ecosystem (Gedia *et al.*, 2009). Though castor is the most preferred host of *S. litura*, the pest status does not remain static on castor and largely influenced by weather parameters. Activity of *S. litura* and its relation to abiotic factors has been investigated in soybean, cotton, groundnut and sunflower ecosystems (Radhika, 2013; Punithavalli *et al.*, 2014; Geetha *et al.*, 2014; Ramesh Babu *et al.*, 2015; Kalola *et al.*, 2017). Since the information available on this aspect on castor is meager, the present study was undertaken for four consecutive years (2012-16) with the primary objective of determining the seasonal dynamics of male moth catches, egg-masses and larval population of *S. litura* in castor. The secondary objective was to understand the role and reliability of weather parameters for predicting the population of *S. litura* in castor.

MATERIALS AND METHODS

Field experiments were carried out during *kharif* season (sowing in July and extending up to February) in four consecutive years (2012-13 to 2015-16) at Narkhoda research farm of ICAR-Indian Institute of Oilseeds Research

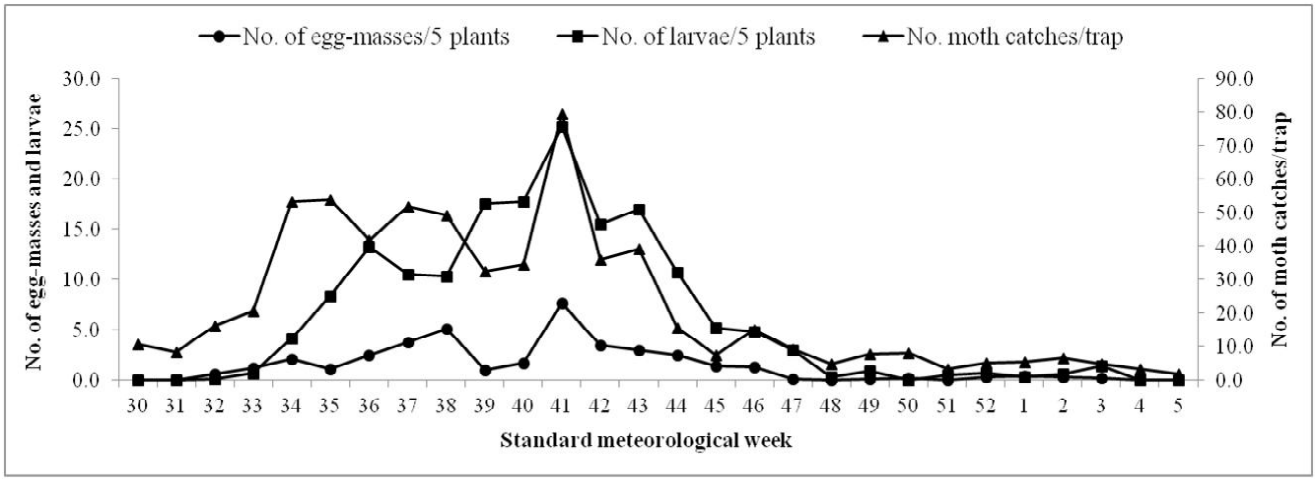

Fig. 1: Seasonal dynamics of *S. litura* populations during castor cropping season at Narkhoda (pooled data of 2012-16)

(Latitude 17° 15´ N, Longitude 78° 18´ E, Altitude 542 mabove mean sea level), Ranga Reddy district, Telangana State to know the seasonal dynamics and assess the influence of weather parameters on *S. litura* incidence in castor. During all the four years of experimentation, castor hybrid DCH-519 was raised in 0.4 ha area with row to row spacing of 90 x 90 cm and all other recommended agronomic practices (except insect-pest management). Weekly observations on the moth emergence, egg and larval population of *S. litura* on castor were recorded starting from germination to harvest of the crop (23 July to 4 February i.e. 30th to 5thstandard meteorological week).The sex pheromone traps were used to record the seasonal dynamics of *S. litura* moths. Commercial sleeve traps with *S. litura* sex pheromone lure (M/s Pheromone Chemicals, Hyderabad, India) were used in the experiment.The traps were positioned 30 cm above the ground, when plants were small and adjusted upwards as required to remain just above the crop canopy. These traps were placed 30 m apart to maintain a density of four traps per acre. The lures were replaced every three weeks. The number of *S. litura* moths caught per week for each individual trap was recorded and were removed from the trap. The mean number of moths caught per trap per week was worked out. Correspondingly, weekly observations on egg-masses and larval population of *S. litura* were recorded in 25 randomly selected plants (5 plants each from five different places from north, east, south, west and centre of the field) throughout the crop season and expressed as number per plant.The data on weather parameters during the crop season were collected from meteorological observatory located at the Narkhoda research farm of ICAR-Indian Institute of Oilseeds Research. The weather parameters such as maximum temperature (°C), minimum temperature (°C), morning relative humidity (RH-I %), evening relative humidity (RH-II %), rainfall (mm), rainy days, bright sunshine hours and wind speed (km h^{-1}) were recorded daily during the crop period. For all the weather parameters, weekly average was worked out except rainfall for which a weekly total was worked out.The weekly data on moth catches, egg-masses and larval population of *S. litura* during cropping season (30th to 5thSMW) were subjected to correlation analysis with corresponding average weekly weather parameters to find out the effects of these abiotic factors on population counts of *S. litura*. The standard week wise pooled data of moth catches, egg-masses and larval population of *S. litura* and weather parameters during critical periods (33rd to 46thSMW) coinciding with the vegetative to primary spike development stage of the crop were subjected to regression analysis by using stepwise regression technique for selection of variables to develop prediction model. The model was validated by comparing the observed *S. litura* populations in castor during *kharif* 2015-16 at Rajendranagar farm of ICAR-Indian Institute of Oilseeds Research, Ranga Reddy district, Telangana State with predicted values by t-test. The test of significance level of 1and 5 per cent for correlation and 5 per cent for regression was determined. SPSS software version 16.0 was used for statistical analysis following the standard procedure.

RESULTS AND DISCUSSION

Seasonal dynamics of S. litura

The weekly mean male moth catches, egg-masses and larval population of *S. litura* on castor during *kharif* seasons of 2012-13 to 2015-16 are presented in Fig. 1. The seasonal dynamics of *S. litura* on castor were similar during all the four years, but the population density differed. The data indicated that the moth catches of *S. litura* was observed throughout the crop season (July to February) from 30th standard meteorological week (SMW) to 5th SMW.Peak trap

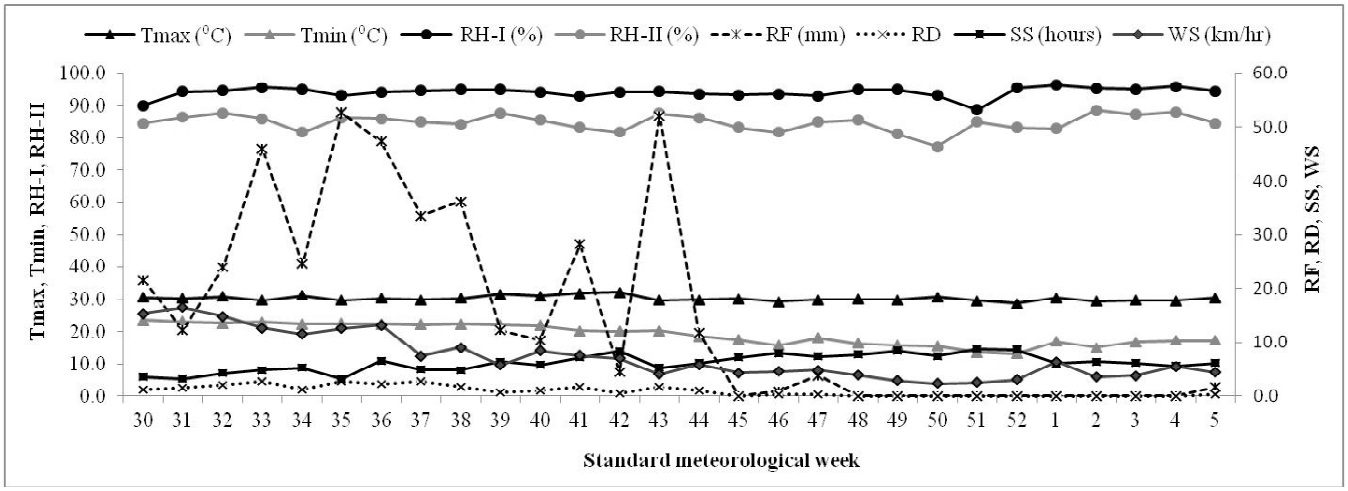

Fig. 2: Weather parameters during castor cropping season at Narkhoda (pooled data of 2012-16)

catches of 44.8 to 124 moths/trap/week was recorded during 33rd SMW (13-19 August) to 43rd SMW (22-28 October) and the moth catches begun to decline from 44th SMW to 5th SMW (29 October - 4 February). Peak oviposition of 2.0 to 14.8 egg-masses/5 plants in castor was recorded during 33rd SMW (13-19 August) to 46th SMW (12-18 November), while the oviposition declined steeply from 47th SMW onwards till the end of the season. Maximum larval incidence of 14.4 to 48 larvae/5 plants was recorded during 35th SMW (27 August-2 September) to 46th SMW (12-18 November). Thereafter, larval population gradually deceased to fewer or nil during the end of the cropping season (Fig. 1).

The present study on seasonal dynamics of *S. litura* in castor revealed peak activity of moths during mid-August to late-October and high infestation of egg-masses and larvae of *S. litura* during mid-August to mid-November coinciding with the vegetative to primary spike development stage of the crop. The year-to-year variation in the abundance of *S. litura* populations could be due to the response to weather parameters and their impact on migration, reproduction as well as abundance of host crops within the regional agro-ecosystem.

Effect of weather parameters on seasonal dynamics of S. litura

Correlation coefficients of the relations between weekly mean moth catches in pheromone trap, oviposition and larval incidence (separately) of *S. litura* in castor pooled over the *kharif* 2012-16 (30th to 5th SMW) and the corresponding weather parameters are shown in Table 1. The results revealed that moth catches and larval population of *S. litura* (each) had significant positive correlation with maximum temperature (r=0.461 and 0.523, respectively), minimum temperature (r=0.613 and 0.422, respectively), rainfall (r=0.711 and 0.444, respectively) and rainy days (r=0.703 and 0.406, respectively). The egg-masses of *S. litura* showed significant negative correlation with morning relative humidity (r = -0.768) and minimum temperature (r= -0.624). This finding was in confirmation with the reports of Khan and Talukder (2017), Radhika (2013) and Prasannakumar *et al*. (2012) who reported strong positive correlation of temperature (minimum and maximum) and negative correlation of relative humidity (morning and evening) with the population of *S. litura* in cabbage, groundnut and potato.

During the period of peak activity of *S. litura*, overall average minimum temperature ranged between 17.6 to 22.9 ºC and the maximum temperature ranged from 29.7 to 32.1 ºC. Weekly total rainfall varied between 4.5 to 52.8 mm and rainy days ranged from 0.5 to 2.8 days. Morning (RH-I) and evening relative humidity (RH-II) ranged between 92.8-95.5 per cent and 81.8-87.8 per cent respectively. Wind speed varied between 4.1 to 13.2 kmh^{-1} and sunshine hours varied between 3.1 to 8.3 hours (Fig. 2).

Development and validation of prediction model

Multiple regression analysis was carried out between weekly mean moth catches, egg-masses and larval population of *S. litura* and weather parameters over years (2012-16) to develop prediction model (Table 2). The results showed that model developed using minimum temperature, rainy days, wind speed and evening relative humidity could explain variability in the *S. litura* moth catches up to 64 per cent. Among all the variables included in the regression equation, only morning relative humidity (RH-I) was found to contribute significantly and showed 59 per cent effect on the population fluctuation of egg-masses of *S. litura* in castor. Rainy days and maximum temperature exerted significant impact on the larval population of *S. litura* in castor showing 51 per cent

Table 1: Correlation coefficient (r) between weather parameters and male moth catches in pheromone trap, egg-masses and larval population of *S. litura* in castor (pooled data of 2012 to 2016)

Weather parameters	Male moth catches in pheromone trap	Egg-masses	Larval population
T_{max}	0.461*	0.193^{NS}	0.523**
T_{min}	0.613**	-0.624*	0.422*
RH-I	-0.007^{NS}	-0.768**	-0.044^{NS}
RH-II	-0.027^{NS}	-0.591^{NS}	0.077^{NS}
RF	0.711**	-0.062^{NS}	0.444*
RD	0.703**	-0.074^{NS}	0.406*
SS	-0.264^{NS}	-0.083^{NS}	0.026^{NS}
WS	-0.349^{NS}	0.435^{NS}	0.046^{NS}

** = Correlation significant at 1% level; * = Correlation significant at 5% level; NS=Not significant

Table 2: Models for prediction of *S. litura* population in castor (pooled data of 2012 to 2016)

Population of *S. litura*	Regression equation	R^2
Male moth catches in pheromone trap (Y)	$Y = 44.96-1.45* T_{min} + 0.22* RD + 0.16* WS + 0.10*RH-II$	0.64
Egg-masses on castor(Y)	Y = 227.0- 2.32*RH-I	0.59
Larval population on castor (Y)	$Y = -28.28+2.25*RD + 1.05*T_{max}$	0.51

Table 3: Observed and predicted *S. litura* populations in castor at Rajendranagar (*kharif* 2015-16)

Standard meteorological week	Moth catches/trap		Egg-masses/5 plants		Larvae/5 plants	
	Observed	Predicted	Observed	Predicted	Observed	Predicted
33	28.5	26.5	2.2	3.1	7.8	12.7
34	22.0	20.4	3.4	3.2	6.6	9.3
35	20.3	20.5	4.2	3.1	3.6	7.8
36	80.3	36.7	5.8	3.3	14.8	13.6
37	65.3	55.4	8.4	3.0	13.2	10.5
38	31.5	28.6	4.2	3.1	6.6	8.2
39	21.3	19.2	4.0	3.1	4.2	5.2
40	18.0	29.0	2.2	2.9	8.2	9.1
41	52.0	49.8	3.2	2.5	5.6	6.7
42	113.0	99.0	10.2	2.4	3.6	6.1
43	44.0	47.0	2.0	2.2	16.4	5.8
MAE		10.3	1.6		0.4	
RMSE		23.8		3.0		4.1

role of these factors when computed together. The pest-weather model was validated by comparing the observed *S. litura* populations in castor during *kharif* 2015-16 at Rajendranagar farm of ICAR-Indian Institute of Oilseeds Research with predicted values.The model was validated satisfactorily and found no significant variation between observed and predicted values ($p > 0.05$). The other statistical parameters *viz*., mean absolute error (MAE) and root mean squared error (RMSE) also indicated the fitting of the developed model (Table 3). The result was supported with findings of Rameshbabu *et al*. (2015) and Selvaraj *et al*. (2010) who reported 35 per cent and 39 per cent variations in *S. litura* male moth catches in soybean and per cent damage in cotton due to the effect of weather factors,

respecively. The results of present study also in coherence with the findings of Sharma *et al*. (2017) who reported that the variables *viz*., temperature, relative humidity and rainfall contributed significantly in explaining the variation of *S. litura* population in sugar beet, soybean and chilli, respectively.

CONCLUSIONS

It is evident from this 4-year study that peak infestation of *S. litura* in castor occurred during mid-August to mid-November coinciding with the vegetative to primary spike development stage of the crop. The correlation analysis indicated that the moth catches and larval population of *S. litura* showed significant positive correlation with weather parameters *viz.,* maximum temperature, minimum temperature, rainfall and rainy days, while egg-masses of *S. litura* showed significant negative correlation with morning relative humidity and minimum temperature during cropping season (30^{th} to 5^{th}SMW). The weather parameters influenced the incidence of *S. litura* populations to the extent of 51 to 64 per cent. The pest-weather model was validated satisfactorily with no significant variation between observed and predicted values of *S. litura* populations. Thus, the model can be used for predicting the population of *S. litura* in castor for optimizing management strategies.

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