Indian Journal of Entomology 84(4): 819-823 (2022) DoI No.: 10.55446/IJE.2021.93

POPULATION DYNAMICS OF *SPODOPTERA EXIGUA* (F.) AND *S. LITURA* (F.) IN SOYBEAN

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ABSTRACT

This study on the population dynamics of *Spodoptera exigua* (F.) and *S. litura* (F.) in soybean was done with observations made from 10 days after germination of the crop for two years. The results revealed that these pests are more abundant from July to August- *Spodoptera litura* (F.) occurred from the first week of July with occurrence of adults increasing with the growing season, and ending with the maturity of the crop. Amongst the current, 1st lag and 2nd lag week weather parameters, the occurrence of adults of *S. exigua* revealed a significant positive correlation with minimum temperature (r=0.716), evening relative humidity- RH (r=0.535), sunshine (0.621) and wind speed (0.661). Maximum temperature and wind speed exhibited a significant negative correlation with incidence of males of *S. litura* whereas, morning and evening RH were positively correlated with the incidence at 1-lag and 2-lag weeks. The incidence of larvae of *S. litura* was significantly influenced by morning RH (r=0.783) in the 2-lag week. The regression equation indicated that an increase in 1 mm rainfall decreased the male moth catches of *S. exigua;* while, incidence of larva was significantly affected with increase in 1% of morning RH; and incidence of *S. litura* larvae was related with maximum temperature of 1°C.

Key words: Soybean, *Spodoptera litura*, *S. exigua*, forecasting, weather factors, population dynamics, pheromone trap, male catches, correlation, regression

Larvae of *Spodoptera* spp., are pests worldwide gaining importance due to its polyphagous nature and causing significant losses in economically important crops. *Spodoptera litura* (F.) and *S. exigua* (Hübner) (Lepidoptera: Noctuidae) are the two important defoliators in soybean, of which the former is the common cut worm. Larvae feeds on the foliage leading to severe defoliation and devastation occurs during reproductive stage in soybean (Chattopadhyay et al., 2019). This species infests over 112 cultivated plants, of which 60 were reported from India (Venette et al., 2003; Khatun et al., 2020). In recent years, *S. litura* has become a serious pest of soybean in some parts of India (Chattopadhyay et al., 2019) and causes severe outbreak (Dhaliwal et al., 2010). The other species, *S. exigua* known as the beet army worm, infests > 90 plants worldwide (Abdullah et al., 2000), of which the main hosts include, soybean, onion, sugar beet, cabbage, cauliflower, brussel sprouts, tomato, maize, cotton, lettuce, peanut, alfalfa, shallot, pastures crops, and various wild hosts (Idris and Emelia, 2001). In recent years, the occurrence of both these *Spodoptera* spp., has increased in soybean causing significant yield losses in Rajasthan. This necessitates formulation of effective IPM strategies, which involve generation of data on their population dynamics. As a part of these population dynamic studies, pheromone baited traps provide a technique to monitor relatively large areas (Punithavalli et al., 2013). Hence, this study based on pheromone trap catches of moths and field incidence of larvae towards exploring their population dynamics.

MATERIALS AND METHODS

The study was conducted at the Agricultural Research Station, Banswara (Rajasthan) (73°2'- 75°E', 23°11'-24°23'N, 220 masl; Humid Southern Plain Zone of Rajasthan- Zone IV b) under rainfed conditions during kharif season (2018, 2019). Recommended agronomic practices were followed with the variety JS-335 raised under unprotected conditions. The weather data were obtained from the metrological unit located at Agricultural Research station, Banswara. The pheromone traps were installed in three locations of approximately 50 m distances at the field site with the help of wooden stick, 10 days after sowing, and placed 2 m high from the ground in the crop canopy. Each trap was rebaited regularly at 25 days interval based on whether it is *S. litura/ S. exigua* to attract male moths. The traps used include- Sleeve traps (PheroSensorTM/ PheroSensorSP, Pheromone Chemicals, Hyderabad, India) with *S. litura* and *S. exigua* sex pheromone lures (SpodoDetectorTM, Pheromone Chemicals, Hyderabad, India and Pest Control India, Bangalore). Data on the incidence of larvae of *S. exigua* and *S. litura* was recorded at a weekly intervals starting from the 2nd week of July till harvest. Five randomly selected sampling units at meter row length (mrl) intervals in the marked field site with number of larvae counted/ mrl were used. The data obtained were pooled and analyzed with simple correlation and regression coefficients with Minitab 19 Statistical Software (trial version) and WASP -Web-Based Agricultural Statistics Software Package of Central Coastal Agricultural Research Institute, ICAR, Goa.

RESULTS AND DISCUSSION

The soybean crop when sampled on weekly basis revealed presence of two *S. litura S. exigua,* the latter was observed from 10 days after germination, was more abundant from July to August (4.00 and 3.00/ mrl, respectively during 2018 and 6 and 5 per mrl, respectively during 2019). This was observed to correspond with moth catches in the pheromone traps and the vegetative stage (Fig. 1). The incidence of both the *Spodoptera* spp., declined thereafter. Similarly, for *S. litura*, the incidence initiated from the first week of July, with peak in moth catches being in the growing season during 2018, and 2019, which decreased with growing season ending; there were three peaks from July to September. Larval population peaks appeared from the end of August to the mid of September corresponding to the reproductive stage (Fig. 2). Similarly, *S. litura* incidence relatively more from end of July to that of September as reported by Chattopadhyay et al. (2019). Overall, moth and larval incidence of of *S. exigua* was abundant during the vegetative stage, and drastically reduced when *S. litura* was at its peak corresponding with the reproductive stages of the crop. Young larvae of *S. exigua* feed on the terminal clusters of the leaves at the seedlings stage and stems, and leaves get skeletonized and almost completely consumed (Mehrkhou et al., 2012). The area under soybean has expanded in the Southern region of Rajasthan recently, and infestation of this pest is in its increasing trend making *S. exigua* as the important pest. The larva makes galleries on the young terminal leaves leading to skeletonization of the leaves with their feeding in a gregarious manner. Later stage larvae feed voraciously on the leaves produce irregular holes. Similar symptoms were reported on onion by Arulkumar et al. (2017). Kamakshi et al. (2019) observed the peak incidence of *S. exigua* in chickpea during the 45th standard meteorological week (SMW).

An initial buildup of the larval incidence in the field was observed during the 2nd week of July which continued up to mid-September, resulting in a severe outbreak of *S. litura* in soybean during August to September (Fig. 2). Thus peaks in pheromone trap catches from August to September were invariably followed with increase in the larval incidence leading to outbreak. The peaks in the occurrence of larvae and adults was during the mid-season from mid-August-mid September usually coinciding with the reproductive stage of crop. Punithavalli et al. (2013) observed the peak appearance of egg masses and larvae of *S. litura* corresponded with the peak activity of male moths during mid-September. Sonkamble and Rana (2019) revealed that the larval incidence of *S. litura* increased reaching a peak at 35th to 39th standard week and

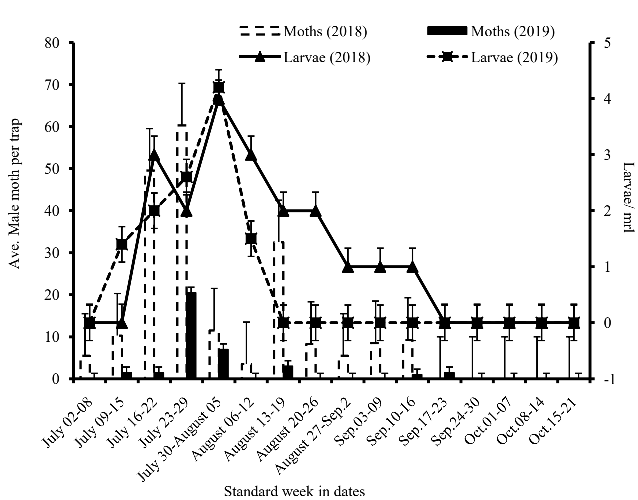

Fig. 1. Seasonal incidence of *S. exigua* at ARS, Banswara (2018-2019)

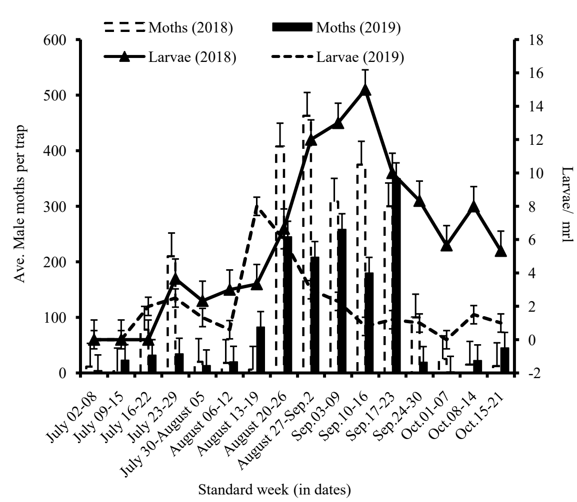

Fig. 2. Seasonal incidence of *S. litura* at ARS, Banswara (2018-2019)

thereafter declined gradually. Overall, larval incidence of *S. exigua* was more during the initial growth phase ie. 7-10 days of germination and increased during the growth stage, and reduced with the late vegetative and reproductive stages (Fig. 1). In recent years, frequent outbreak of *S. litura* have been observed in the soybean (Prasad et al., 2013; Dhaliwal et al., 2010); in 2007, such an outbreak in soybean occurred during 38th SW, corresponding with rainfall of 195 mm and sudden temperature rise. This concludes that continuous rainfall followed by dry conditions favour its incidence on soybean (Ramesh Babu et al., 2015). A similar condition was reported by Choudhary and Bajpai (2006). In this period, the pest may undergo a shorter lifecycle and feed on the reproductive stage with overlapping generations. Xue et al. (2010) reported that the larvae in second-generation developed faster, survived more, had heavier pupae and oviposited more. Prasad et al. (2013) reported on the frequent outbreaks of *S. litura* on soybean. Widespread and frequent rainfall during June-September, and other rainfall events reflected in the low incidence of *S. litura*.

The correlation coefficients of the incidence of larvae, pheromone trap moth catches with weather factors reveal that both the *Spodoptera* spp. were greatly influenced; amongst the current, 1st lag and 2nd lag week weather parameters, the mean trap catches of *S. exigua* exhibited a significant positive correlation with minimum temperature (r=0.716*), evening relative humidity- RH (r=0.535*), sunshine (0.621*) and wind speed (0.661*); whereas, the other weather parameters like maximum temperature, morning RH and rainfall showed a non-significant positive correlation. Similarly, the larval incidence was observed to be significantly positively correlated with minimum temperature and wind speed (except sunshine which showed a significant negative correlation in case of *S. exigua* (Table 1).

Table 1. Population dynamics of *S. exigua* and *S. litura* on soybean- pheromone trap catches and larval incidence vs weather factors (2018-2019)

Weather parameters	Moth (n=16)			Larvae (n=16)		
	Current	1st lag	2nd lag	Current	1st lag	2nd lag
S. exigua						
Max temp (°C)	-0.387	-0.111	0.023	-0.370	-0.110	-0.016
Mini. Temp (°C)	0.716*	0.706*	0.536*	0.624*	0.644*	0.592*
Mor. RH (%)	0.431	0.176	0.019	0.469	0.131	0.035
Eve. RH (%)	0.535*	0.349	0.147	0.432	0.323	0.187
Rainfall (mm)	0.005	-0.242	-0.004	0.025	-0.323	-0.235
Sun shine (hrs)	0.621*	-0.429	-0.314	-0.530*	-0.366	-0.298
Wind speed (km/ hr)	0.661*	0.716*	0.736*	0.687*	0.710*	0.587*

Insect stage	Regression equation for moth catches and larvae	R^2
Moths (n=16)	Y =- 13.285 +(0.121) x1+(0.543) x2+(0.017) x3+(-0.025) x4+(-0.017)x5+(-0.096*)x6 +(0.030) x7+0.847 (SE)	0.77*
Larvae (n=16)	Y = -3.49 +(-0.101) x1+(0.192) x2+(0.068) x3+(-0.049) x4*+(-0.005) x5+(0.042) x6 +(0.097) x7+0.268 (SE)	0.81*

S. litura

Weather parameters	Moth (n=16)			Larvae (n=16)		
	Current	1st lag	2nd lag	Current	1st lag	2nd lag
Max Temp (°C)	-0.458	-0.588*	-0.514*	-0.398	-0.577*	-0.796*
Mini. Temp (°C)	0.191	0.147	0.063	-0.210	-0.199	-0.295
Mor. RH (%)	0.425	0.530*	0.516*	0.327	0.498*	0.783*
Eve. RH (%)	0.406	0.492*	0.542*	0.174	0.320	0.684*
Rainfall (mm)	0.229	0.296	0.018	0.147	-0.074	0.025
Sun shine (hrs)	-0.292	-0.451*	-0.563*	-0.095	-0.212	-0.499*
Wind speed (km/ hr)	-0.212	-0.166	-0.044	-0.579*	-0.516*	-0.388

Insect stage	Regression equation for moth catches and larvae	R^2
Moths (n=16)	Y = -5.063+(1.164) x1+(3.993) x2+(-0.129) x3+(-0.197) x4+ (-0.005) x5+(-0.289) x6 +(-3.07) x7+6.150 (SE)	0.57*
Larvae (n=16)	Y = 2.024 +(-0.331) x1*+(0.331) x2+(0.119) x3+(-0.102) x4+(-0.001) x5+(-0.017) x6 +(-0.161) x7+0.404 (SE)	0.80*

*Significant at p=0.05; x1=maximum temp. (°C); x2=Minimum temp. (°C); x3=Morning Humidity (%); x4=Evening humidity (%); x5=Rainfall (mm); x6=Sunshine hours; x7=Wind speed (km/ hr)

Kamakshi et al. (2019) observed amongst current, 1-lag, 2-lag and 3-lag week weather parameters, the occurrence of male moths showed a significant positive correlation with maximum temperature (Tmax) and minimum temperature (Tmin), and negative correlation with morning RH of 2-lag week; and sunshine hours/day (SSH) of the current week had a significant negative association. In case of *S. litura*, among the current, 1-lag and 2-lag week weather factors, maximum temperature and wind speed showed significantly negative correlation with male moth catches whereas, morning and evening RH, a positive one with 1-lag and 2-lag weeks. Larval incidence of *S. litura* was significantly influenced by morning RH (r=0.783) in 2-lag week; maximum temperature, sunshine and wind speed were negatively correlated as shown by the data of current, 1-lag and 2-lag week (Table 1). Chattopadhyaya et al. (2019) reported that the occurrence of moths showed a significant positive correlation with minimum temperature and morning RH.

These results are contradictory to those obtained with castor and groundnut which showed that the occurrence of male moths had a significant positive correlation with maximum temperature, afternoon RH and sunshine hours and a negative one with rainfall (Bhalani et al., 2004). The maximum temperature had a significant positive correlation with trap catches, while it was a significant negative one with rainfall and RH in castor (Gedia et al., 2007). All the weather parameters except morning RH exhibited a highly significant negative correlation in case of trap catches of *S. litura* in cotton (Prasad et al., 2008); wind speed and evaporation influenced the activity of moths. In potato cut worm, there was a negative correlation observed with morning/afternoon RH and rainfall, while it was a positive one with maximum and minimum temperature and wind speed (Prasannakumar et al., 2012).

Weather-based regression model developed using moth catches and larval incidence of *Spodoptera* spp., with data observed during current, 1-lag and 2-lag week are given Table 1; these indicated that weather parameters contribute 77 and 81% variations in *S. exigua* moth catches and larval incidence, respectively; and an increase in 1 mm rainfall decreased the moth catches (Table 1). Whereas, the larval incidence was significantly affected by increase in 1% of morning RH. Sonkamble and Rana (2019) developed the multiple linear regression model and reported that the influence of weather parameters was 54.2 to 70.9% in *S. litura*. Kamakshi et al. (2019) with *S. exigua* in chickpea showed that every $1^{O}C$ decrease in maximum temperature and increase in 1% RH increased the moth catches. The present results reveal that weather factors influence the moth catches and larval incidence of *S.litura* to an extent of 57 and 80%, respectively (Table 1); reduced larval incidence was observed when the maximum temperature increased by $1^{0}C$; and an increase in 1% of morning RH reduced the moth catches in castor (Gedia et al., 2007). These results are contradictory to the present study in soybean. All-weather parameters combined with rainfall significantly contributed to variations in the male moth catches of *S. litura* in soybean.

ACKNOWLEDGEMENTS

The authors thank the Director Research, MPUAT, Udaipur for constant support; and facilities established through RKVY project at the Agricultural Research Station, MPUAT, Banswara are acknowledged.

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(Manuscript Received: March, 2021; Revised: August, 2021;
Accepted: September, 2021; Online Published: November, 2021)
Online First in www.entosocindia.org and indianentomology.org Ref. No. e21074