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# Analysis of outbreak of tobacco caterpillar, *Spodoptera litura* (Fabricius) on soybean

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## ABSTRACT

An investigation was carried out to study the effect of various weather parameters on the occurrence of larva and adult population of *Spodoptera litura* and their factors for outbreak of this pest in soybean in Banswara, Rajasthan. The moth populations of *S. litura* were active from August to mid-October and decreased sharply in late October. The peak appearance was observed during September-October months and corresponded with peak activity of egg masses and larval population in soybean contributed to the outbreak of this pest during the reproductive stage of the crop. Overall correlation studies confirmed that the fluctuations in the male moth catches of *S. litura* per pheromone trap is mainly due to weather factors like, maximum temperature, rainfall, sunshine and wind speed. Moth population in pheromone traps will be used as a warning situation indicating the occurrence of larvae in the host for potential attack and to initiate timely management of *S. litura* in soybean.

***Key words:*** Spodoptera litura, pheromone trap, rainfall, soybean.

India is one of the major oilseeds producing country in the world and these are the second largest agricultural commodity in India after cereals occupying 13-14% of gross cropped area (Sreekanth *et al*., 2013). Soybean (*Glycine max* (L.) Merrill) is a oil seed crop contains about 40-42 per cent protein (Netam *et al*., 2013). It is the fifth largest oilseed crop in India next only to castor, safflower, groundnut and rapeseed mustard (Sinha and Netam, 2013). In *kharif*, 2013 soybean covers an area of approximately 120.32 lakh hectares with an annual production of 129.83 lakh Mt (www.soya.org.in). The productivity of soybean is less as compared to world average (1.8 t $ha^{-1}$) and Asia (1.3 t $ha^{-1}$) and this is due to biotic and abiotic factors during the crop growth period (Sinha *et al*., 2013).

As many as 275 insect species have been recorded attacking soybean crop in India (Salunke *et al*., 2002). Among them, leaf hopper, white fly, girdle beetle, Bihar hairy caterpillar, semi looper and tobacco caterpillar were common in this zone iv b of Rajasthan. Among the different defoliators, tobacco caterpillar (*Spodoptera litura* Fab.) is a serious and devastating polyphagous pest. Larvae feeds on the foliage results in complete defoliation and in case of severe infestation, complete devastation of soybean crop occurs. This pest has been reported to attack over 112 cultivated plant species of which 60 are from India and distributed in much of Asia, including tropical, subtropical and temperate areas and Oceania (Venette *et al*., 2003). Yield losses in soybean are directly associated with higher larval densities and increased defoliation (GeonHwi *et al*., 2006). The intensive use of insecticides for control of this pest has resulted in high levels of resistance to virtually all commercial inssecticides in many parts of the world. In recent years, the tobacco caterpillar has become a serious pest on soybean in some parts of India and causes severe outbreak of this pest in soybean (Dhaliwal *et al*., 2010).

Pheromone baited traps provide a technique to monitor relatively large areas for the presence of lepidopterans moths (Punithavalli *et. al*., 2013). Therefore, the management of tobacco caterpillar at their peak time is to be needed for maximization of yield of soybean. Weather plays an important role on the population dynamics and distribution of pests. Temperature, rainfall, relative humidity, sunshine hours and wind speed are the chief weather parameters influencing the pest incidence. Activity of *Spodoptera litura* in relation to weather factors have been investigated in soybean cropping systems (Prasad *et al*., 2013 and Punithavalli *et al*., 2013). Therefore, a location based model for pest forecast in soybean crop is an essential for effective integrated pest management strategy. Hence an attempt has been made for five consecutive years to monitor and develop pest forewarning models based on pheromone trap catches of moths and field population (eggs and larvae) that could help for farmers in timely management of *S. litura* in soybean crop.

## MATERIALS AND METHODS

Field experiments on soybean were conducted under rainfed conditions during *Kharif* season for five consecutive years (July-October, 2009-2013) at Agricultural Research Station, Borwat Farm, Banswara using JS-335 as a test variety. This station was located between 73°2' to 75° E' longitude and 23°11' to 24°23' N latitude at an altitude of 660 m above mean sea level, in Humid Southern Plain Zone of Rajasthan (Zone IV b). Recommended agronomic practices like fertilizer application, weeding and irrigation etc were taken up. The crop was raised under unprotected conditions. Data pertaining to the age of the crop and pheromone trap catches of *S. litura*, eggs and larval population incidence was taken at weekly interval till the harvest of the crop. Weather parameters like maximum and minimum temperatures, morning and evening relative humidity, rainfall (mm), sunshine hours, and wind speed (km $hr^{-1}$) were recorded from the metrological unit located at Agricultural research station, Banswara. The data were analyzed by using simple correlation and regression tools with the help of Indostat software to workout the relationship between weather parameters and pest incidence.

## RESULTS AND DISCUSSION

### *Fluctuations of adult moth population density with the traps*

The studies indicated that the population of male moths in pheromone trap was appeared in 1st week of July and continues upto mid-October (Fig. 1). During the stages from vegetative to reproductive stage of soybean crop, the adult moth population per trap was high in 2013 (4472 male moths/trap) whereas the mean population of 2495 male moths per trap was observed from 2009 to 2012. It indicates that the activity of *S. litura* increased according to the climatic condition of the zone. On the mean data of 2009 to 2012, the adults were started trapping in first week of July, the size of catches increased rapidly and the peak appearance was observed during 34 and 35th standard week (3rd and 4th week of August) and also during 39th standard week whereas, during 2013, four peaks were observed. The maximum population was observed from 36th to 41st Standard weeks. These results are similar to the observation made by Punithavalli *et al* 2013 in soybean cropping system. Whereas, the peak period of moth catches was observed in 36th, 43rd and 44th standard weeks and 40th and 43th standard week in castor and groundnut crop, respectively (Gedia *et al*., 2007 and Singh and Sachan 1993). Prasannakumar *et al* (2012) reported peak moth population during 37th SW in potato crop.

Male moth populations of *S. litura* were active from August to mid-October and decreased sharply in late October. Similarly, peak period of *S. litura* male moths was observed on groundnut and soybean during the rainy season (July-October) (Singh and Sachan 1993).

### *Correlation studies*

The correlation coefficients worked out between the weather parameters and pheromone trap moth catches in soybean. The results indicated that the revealed that the tobacco caterpillar populations recorded on periodically from the pheromone traps was greatly influenced by agrometeorological conditions. Variations in the weather factors on the influence of male moth catches per trap may be due to changes in the climatic factors during the different years of observation. Overall correlation studies from 2009-2012 confirmed that the fluctuations in the male moth catches of *S. litura* per pheromone trap is mainly due to weather factors like, maximum temperature, rainfall and sunshine (Table 1). Among the weather factors, sunshine significantly and negative influence on the male moth population per trap whereas maximum and minimum temperature, rainy days and wind speed negatively influence the male moth population per trap and all other weather factors were negatively or positively influence the population of moths but these were showed non-significant. These results are contradictory to the results in castor and groundnut where the population of male moth catches had a significant positive correlation with maximum temperature, afternoon relative humidity and sunshine hours and negative correlations with rainfall (Bhalani *et al*., 2004). Maximum temperature had significant positive correlation with trap catches while trap catches had significantly negative correlation with rainfall and relative humidity in castor (Gedia *et al.,* 2007). All the weather parameters except morning relative humidity had highly significant negative influence on the pheromone trap catch of tobacco caterpillar in cotton (Prasad *et al*., 2008). The weather parameters *viz.*,wind speed and evaporation influenced the activity of the moths. The correlation matrix on trap catches of potato cut worm exerted a negative association with morning relative humidity; after noon relative humidity and rainfall and a positive relation with maximum temperature; minimum temperature and wind speed (Prasannakumar *et al*., 2012). The differences in results may be a function of differences in place and crops.

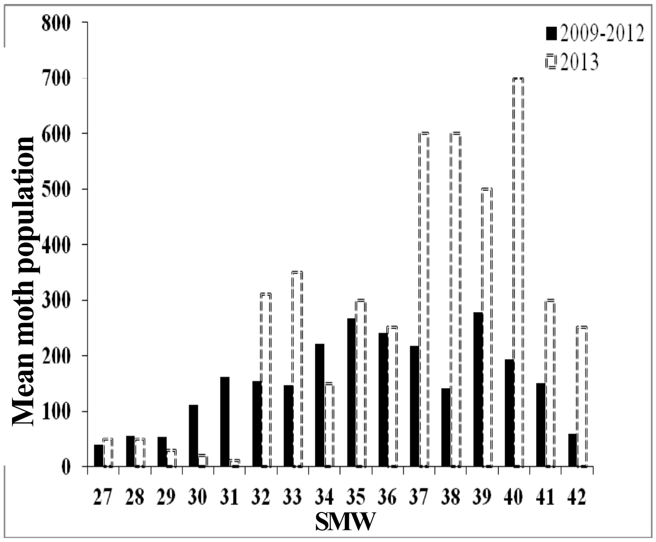


**Fig. 1:** Weekly male moth catches in pheromone trap of *S. litura* observed in soybean

***Regression analysis***

Regression equation was developed using pooled data as given below.

$Y=574.49+(-13.69x_1)+(29.43x_2)+(-10.18x_3) + (0.64x_4) + (0.53x_5) +(-21.66x_6)+ `(-23.99^{**}x_7)+(-15.60^{*}x_8) +817.61$
$R^2=0.35$

This indicated that the various weather parameters caused 35 per cent variations in *S. litura* male moth catches but non-significant. The regression equation indicated that increase in 1 sunshine hour significantly decreased the male moth catches of *S. litura* of 23.99 per trap per week similarly; increase in 1 km/hr wind speed decreased the moth population of *S. litura*. Other factors influence the moth population negatively or positively but non-significant. Based on this regression analysis, during 2013 a prediction model was developed and applied in the field. Analysis revealed that the variations in *S. litura* male moth catches were significantly influenced by various weather parameters. Increase in wind speed by 1 km/hr significantly decreased the moth population of *S. litura* by 80 per trap per week. Increase in 1 per cent morning humidity reduced the moth catches in castor (Gedia *et al*., 2007). These results are contradictory of the present study in soybean. All weather parameters combined with rainfall significantly contributed in variations in the male moth catches of *S. litura* in soybean.

**Table 1:** Correlation co-efficient between pheromone trap catches of *Spodoptera litura* and weather parameters on soybean (2009-2012)

| Year | Maxi. temp. | Mini. temp. | Mor. RH | Eve. RH | Rainfall | Rainy days | Sunshine | Wind speed |
|---|---|---|---|---|---|---|---|---|
| Pooled 2009-2012) (n=64) | -0.201 | -0.061 | 0.054 | 0.093 | 0.161 | -0.055 | -0.314* | -0.123 |

**Significant at 1% *Significant at 5%

**Table 2:** Validation of simple prediction rule for *S. litura* in soybean at Banswara

| year | Average rainfall mm | Actual rainfall mm (27-42 SW) | Base moth population (27-31 SW) | Moth population (32-35 SW) | Moth population (36-42 SW) | Sudden rise in temperature and sunshine hrs | Level of infestation |
|---|---|---|---|---|---|---|---|
| **2007** | 910 | 1429.7 | - | - | - | 39-42 SW | Severe |
| **2009** | 696 | 662.5 | 98 | 985 | 898 | 37-42 SW | Normal |
| **2010** | 496 | 489.3 | 347 | 1094 | 909 | 38-42 SW | Normal |
| **2011** | 973 | 936.5 | 1020 | 265 | 670 | 39-42 SW | Normal |
| **2012** | 1074 | 1063.7 | 124 | 820 | 2807 | 36-42 SW | Severe |
| **2013** | 1002 | 952.6 | 161 | 1111 | 3200 | 36-42 SW | Severe |

2007 & 2008 moth population was not recorded but during, 2007 outbreak of *S. litura* in soybean at Banswara Standard week: 27-31 (2nd July to 5th August); 32-35 (6th August to 2nd September); 36-42 (3rd September to 21st October)

**Table 3:** Observed and predicted *Spodoptera litura* moth population during September-October in Banswara, Rajasthan

| Standard week | Observed value | Predicted value |
|---|---|---|
| 36 | 278 | 252 |
| 37 | 216 | 233 |
| 38 | 142 | 225 |
| 39 | 279 | 199 |
| 40 | 195 | 156 |
| 41 | 150 | 193 |
| 42 | 59 | 82 |
| 43 | 1321 | 1342 |

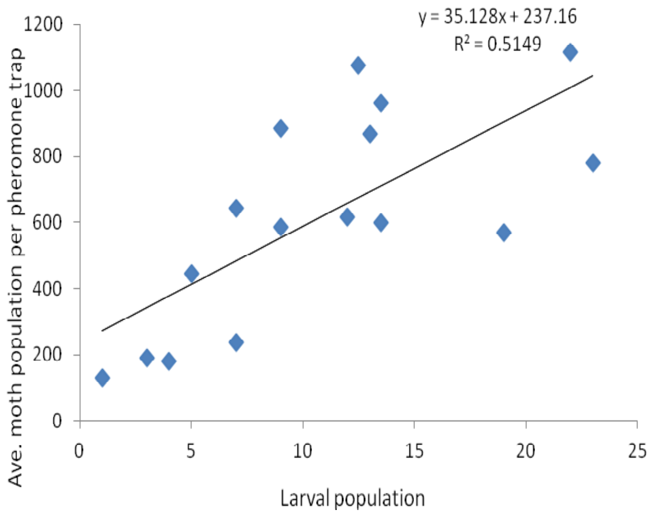


**Fig. 2:** Relationship between pheromone moth catches and larval population of *S. litura* in soybean (2009-2012)

***Relationship between pheromone trap catches and corresponding field population***

Under field conditions, pest monitoring is applicable when the relationship between moth catches in pheromone trap and corresponding larval population in field are consistent and good (Srivastava *et al*., 2010). During 2009, the egg masses were noted during 32nd standard week in soybean. However, the increase in moth catches in the trap was not paralleled with the egg masses in the field. Similarly, the larval population of *S. litura* was not correlated with the increase in population of moth catches in soybean. Similar results were also observed during 2010 and 2011. Overall results showed that the initial increase in the moth population in pheromone trap did not show any significant effect on the field infestation of larvae in soybean crop. This may be due to the polyphagous nature of the pest which prepares other hosts other than soybean during *Kharif* season. On the basis of pooled data, the correlation between larval counts and pheromone trap catches were significantly positive. Similar observation was also made during 2013. Initial buildup of larval population in the field was observed during the 3rd week of August and continues build up to mid-October resulted in severe outbreak of *S. litura* in soybean during September to October. This indicates that during 2012 & 2013, the more peaks in pheromone trap catches of *S. litura* in September month were invariably followed by an increase in the number of larvae population and contributed to the outbreak of the pest in the soybean field. The peak population of larvae also coincided with the reproductive stage of the soybean crop. Similarly, Punithavalli *et al* (2013) studied the seasonal occurrence of *S. litura* in a soybean ecosystem. The peak appearance of egg masses and larvae of *S. litura* corresponded with the peak activity of male moths recorded during mid-September.

Pooled weekly data from 2009-2012 indicated that there existed a significantly positive correlation between moth catches in pheromone trap and larval population of *S. litura* in soybean with r value of 0.514. The regression equation is shown in Fig. 2. Punithavalli *et al* (2013) reported on correlation studies indicated that weekly trap catches were linearly and positively correlated with masses and larval populations in soybean crop.

***Prediction model for forecasting of S. litura in soybean***

Forecasting of pest incidence in field crops is mainly based on the weather parameters, monitoring of pests, previous record of incidence (outbreak) of particular pest, crop stages and cropping systems etc. The first prediction model for *Helicoverpa armigera* was made by National Center for Integrated Pest Management (NCIPM), New Delhi. In the present study, several factors like, rainfall pattern, base moth population (27-31 SW), moth population during 32-42 SW and sudden rise in temperature and sunshine hours (Table 3) were taken into account to develop location specific forecast models for the polyphagous pest, *S. litura* in soybean.

In recent years, frequent occurrences of outbreak of *S. litura* have been observed in the soybean field (Prasad *et al*., 2013). In 2007, outbreak of this pest was appeared in soybean crop during 38th SW. During this week, the rainfall of 195 mm and sudden rise in temperature contributed the egg and larval population in the farmers field. This concludes that continuous rainfall then followed by dry condition favours the incidence of this pest on soybean field. Similar condition was reported by Choudhary and Bajpai, 2006. In this period, pest may undergo shorter life cycle and feeds on the reproductive stage of the soybean crop and generates overlapping populations in the field. Insecticide resistance in *S. litura* due to continuous exposure of same group of insecticides, misuse or overdose of pesticides and low activity of natural enemies may be resulted in outbreak of this pest. Xue *et al* (2010) reported that the larvae in second generation developed faster, survived more, had heavier pupae and oviposited more. Similarly, Gao *et al* (2004) identified several factors like monoculture, increased acerage of preferred crops, high temperature and less rainfall in summer, misuse of pesticides that cause resistance of insecticides and less natural enemies.

In 2012 another outbreak of this pest was reported in this zone. The study indicates that the outbreak of *S. litura* was observed during 36$^{th}$ SW in which the following factors were contributed *i.e.* the surplus rainfall compared to normal rainfall, huge moth population during 36-42 SW when compared to previous SW (Table 2). Then followed by increased in temperature and sunshine hours contributed the subsequent increase in the population of *S. litura* and the corresponding field population of the pest in soybean crop upto 42$^{th}$ standard week. The similar conditions were existed throughout the September and October months contributed to the huge populations of moths in pheromone trap then followed by field population of *S. litura* and contributed to the outbreak of this pest. Prasad *et al* (2013) reported the frequent outbreaks of *S. litura* on soybean. Analysis indicated that the occurrence of widespread and frequent rainfall during June-September, other rainfall events reflected in the low incidence of *S. litura*. They reported rainfall events coinciding with adult emergence time had a detrimental effect on pupal survival and moth emergence initiating the next generation. However, in the present study during the rainfall events coupled with huge population of moth catches during September-October months in pheromone traps followed by dry conditions favoured the moth emergence initiating subsequent overlapping generations in soybean during the outbreak years (2007, 2012 & 2013) when compared to normal population observed during (2009-2011).

The observed and predicted values of moth population density during September to October are shown in Table. 3. The observed values for pheromone trap catches from 2009 to 2012 are found close to the forecast value for these years showing the accuracy of the model for the zone similar observations were made during 2013. It has been observed that *S. litura* abundance depends on the total moth catch per trap during September, weather factors like temperature and sunshine for the succeeding standard weeks of the September and October months.

## CONCLUSIONS

Pheromone traps can be used for the prediction of numbers of *S. litura* eggs and larvae in soybean fields. Thus, it is clear from the results that the rainfall pattern (Surplus than Normal RF during the current year), moth catches in pheromone trap during September and October, sudden rise in temperature and sunshine hours would decide the outbreak of *S. litura* in soybean crop. It may conclude that *S. litura* outbreaks are more likely to occur during rainy seasons in soybean and coupled with moth catches during September-October months. A understanding of population dynamics of *S. litura* may provide the basis for forecasting outbreaks in soybean. Based on the developed model for the severity of *S. litura* in soybean, the farmers could be warned of pest outbreak during season for this Zone IV b.

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