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Determination of an action threshold for tobacco caterpillar, *Spodoptera litura* (F.) based on pheromone trap catches in castor (*Ricinus communis* L.)

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ABSTRACT

Field experiments were conducted for four years to study the relationship between tobacco caterpillar, *Spodoptera litura* (F.) (Lepidoptera: Noctuidae) moths captured on synthetic sex pheromone trap and associated field population and damage to castor for determining action threshold for this insect, based on number of moth catches in pheromone trap. Peak trap catches, oviposition and larval incidence of *S. litura* was recorded during September to October. Economic damage of more than 25% defoliation by *S. litura* was observed during September to November. Pooled analysis of four years data revealed that current week trap catches of moths was found to be significant strong positive correlation with oviposition (r = 0.852 to 0.855), while two and three week after moth catches in trap recorded significant strong positive correlation with larval incidence (r = 0.814 to 0.873) and per cent defoliation (r = 0.868 to 0.892) of *S. litura* in the field, respectively. Regression analysis revealed that the per cent defoliation in the field was a linear function of three week after moth catches in pheromone trap, indicating the possibility of assessing the level of damage from trap catches. From this relationship, the pheromone trap catches corresponding to the economic threshold level of 25% defoliation of *S. litura* on castor was estimated to be 81.4 moths/trap/week. Thus, pheromone trap based action threshold identified can be used to forecast the seasonal status of *S. litura.*

Key words : Action threshold, castor, forecasting, pheromone traps, *Spodoptera litura*.

INTRODUCTION

Castor (*Ricinus communis* L.) is one of the industrially important non-edible oilseed crops grown in India. Among major castor growing countries in the world, India ranks first with 70% of area and 87% of world castor production (Sarada *et al*., 2015). During recent years, castor has emerged as a commercial crop with immense export potential earning valuable foreign exchange. Though castor productivity in India is more than world average, there are several production constraints, of which insect pests dominate the scenario. The tobacco caterpillar, *Spodoptera litura* (F.) (Lepidoptera: Noctuidae) is considered the most destructive insect pest of castor damaging the crop throughout the *kharif* season. The newly hatched larvae feed gregariously and skeletonise the leaves giving 'mesh' like appearance. Later they disperse, become solitary and nocturnal in habits, spending the day hiding in the soil or in the leaf litter and cause complete defoliation (Duraimurugan and Srinivas, 2017). Farmers often only notice the presence of the larvae after the damage already occurred. An important prerequisite for successful management of *S. litura* in castor has been the implementation of an intensive monitoring program. Though monitoring of *S. litura* population using sex pheromone trap has been reported in castor (Satyagopal *et al*., 2014), it is not clear how to use the monitoring data to determine a reliable 'action-threshold' which could be useful to decide whether or not to start chemical treatment. Castor crop can compensate 25% defoliation at any stage, but the yield reduction was significant only beyond 25% defoliation (Lakshmamma *et al*., 2009). This paper describes the development of an action threshold for *S. litura* based on relationship between pheromone trap catches and damage to foliage assessed over a period of 4 years and discusses how the pheromone trap data can be useful to forecast damage caused by *S. litura* in castor.

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MATERIALS AND METHODS

Study sites : Field trials were conducted in two locations at Narkhoda Research Farm (Latitude

17.25ºN, Longitude 78.33ºE, Altitude 563 m a.s.l.) and Rajendranagar Research Farm (Latitude 17.15ºN, Longitude 78.18ºE, Altitude 536 m a.s.l.) of ICAR-Indian Institute of Oilseeds Research, Hyderabad, Telangana consecutively for four years during *kharif* 2012-13 to 2015-16. In both the sites, castor hybrid DCH-519 was raised in one acre area with a spacing of 90 cm between rows and 90 cm between plants. The crop was sown during second fortnight of July and recommended agronomic practices except for insecticide application were followed during all the four years of experimentation.

Pheromone traps and lures : Sleeve trap (Phero-Sensor™, Pheromone Chemicals, Hyderabad, India) with *S. litura* sex pheromone lure (Spodo-Detector™, Pheromone Chemicals, Hyderabad, India) were used in the experiment. At each locality, four pheromone traps were installed in the castor field, approximately 5 m from the field edge and monitored the moth catches throughout the crop season (July to February, i.e. from sowing to harvest). Traps were randomly distributed with 30 m distance between them and positioned about 30 cm above the ground when plants were small and adjusted upwards as required to remain just above the crop canopy. The lures were replaced every three weeks.

Monitoring of S. litura population and damage assessment : Moth catches in pheromone traps were monitored weekly throughout the crop season (23 July to 4 February i.e. 30th standard week to 5th standard week). 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 calculated for each site from these cumulative counts. Correspondingly, weekly observations on egg-masses, larval populations and foliage damage caused by *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). The per cent defoliation was calculated by using the following formula

$$\text{Per cent defoliation} = \frac{\text{No. of infested leaves/plant}}{\text{Total no. of leaves/plant}} \times 100$$

The foliage damage was categorized on 0-4 scale (0 = No foliage damage; 1 = less than 25% foliage damage; 2 = 26 to 50% foliage damage; 3 = 51 to 75% foliage damage and 4 = 76 to 100% foliage damage) to facilitate the analysis and interpretation of the data.

Statistical analysis : Pooled analysis was carried out for four years and the statistical analyses were performed using the SPSS 16.0 statistical package. The data on weekly male moth catches/trap were subjected to correlation analyses with mean egg-masses, larval numbers, and per cent defoliation damage. Regression analysis was carried out with moth catches in the pheromone traps and per cent defoliation and the equation is given in Table 2. Action threshold was calculated at 26-50% foliage damage (grade 2 on 0-4 scale) as it is considered as the economic threshold level to initiate appropriate insect management strategies.

RESULTS AND DISCUSSION

Seasonal dynamics of moth catches in trap, population and field damage of S. litura on castor : The results of pooled data of the four years (*kharif*, 2012-13 to 2015-16) on moth catches in pheromone trap and oviposition, larval infestation and per cent defoliation of *S. litura* on castor in two locations are presented in Fig. 1. The weekly data indicated that the trap catches of *S. litura* was observed throughout the crop season (July to February) from 30th meteorological week (MW) to 5th MW. Peak trap catches of 96.3 and 79.6 moths/trap/week was recorded during 38th MW (17-23 September) and 41st MW (8-14 October) at Rajendranagar and Narkhoda, respectively. In both the locations, more number of moth catches (32.4 to 96.3 moths/trap/week) was observed during 34th MW (20-26 August) to 43rd MW (22-28 October) and the trap catches declined from 44th MW to 5th MW (29 October - 4 February). Peak oviposition of 7.7 and 3.8 egg-masses/5 plants in castor was recorded during 41st (8-14 October) and 42nd MW (15-21 October) at Narkhoda and Rajendranagar, respectively. Maximum larval incidence of 9.1 to 13.6 larvae/5 plants and 10.3 to 25.2 larvae/5 plants was recorded during 36th to 43rd MW (3 September - 28 October) at Rajendranagar and Narkhoda, respectively. Mean defoliation damage grade during the season ranged from 0 to 2 in both the locations. Maximum of defoliation damage grade of 2.0 (i.e. 26 to 50% foliage damage) was observed during 40 to 41st MW (1-14 October) and 37 to 44th MW (10 September - 4 November) at Rajendranagar and Narkhoda, respectively.

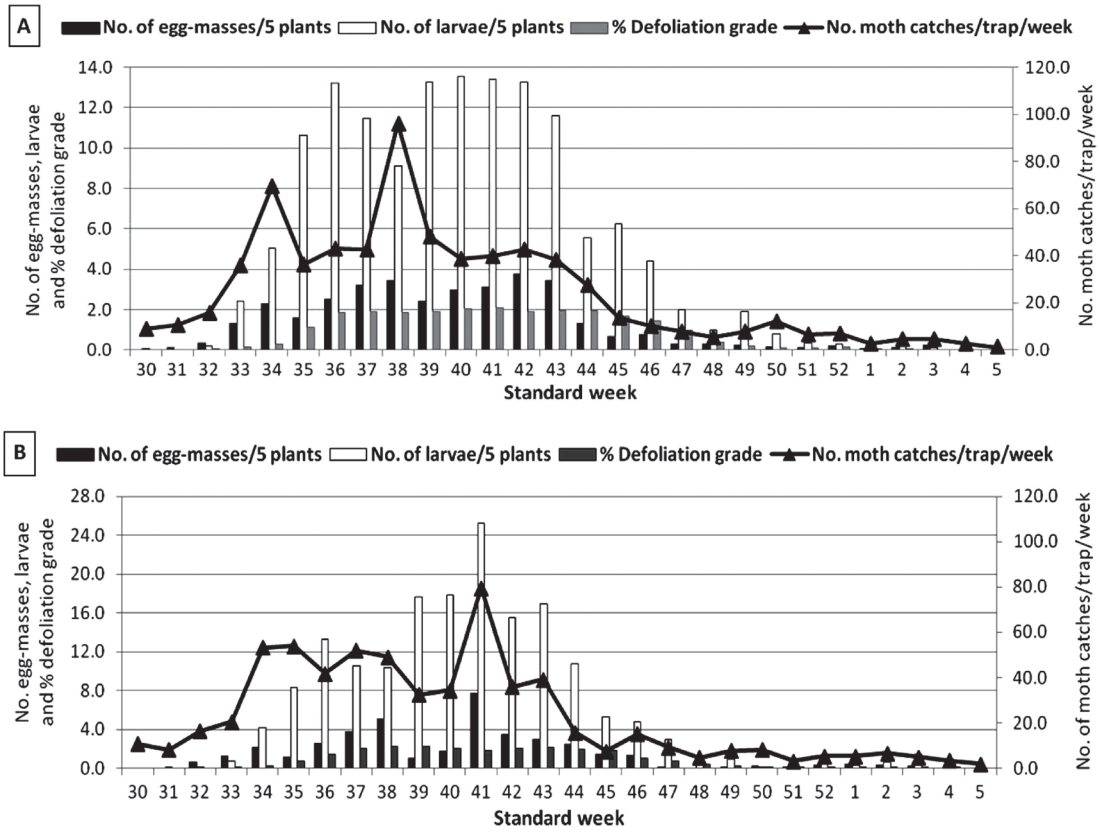

Fig. 1. Pooled weekly mean male moth catches in pheromone traps and abundance of egg-masses, larval population and per cent defoliation of *Spodoptera litura* during castor cropping season (*kharif* 2012-13 to 2015-16) at two locations (A = Rajendranagar; B = Narkhoda)

Effective insect pest management relies on the early detection of insect pests. Pheromone-baited traps provide a technique to monitor lepidopteran moths. Pheromone traps baited with synthetic pheromone lures are species specific and can depict seasonal flight and their fluctuation over the period of the cropping season (Punithavalli *et al*., 2014). Seasonal occurrence of *S. litura* as reflect by pheromone trap catches has been reported in soybean (Chiu *et al*., 1993; Punithavalli *et al*., 2014), groundnut (Gedia *et al*., 2009; Ranga Rao *et al*., 1991), sunflower (Geetha *et al*., 2014; Jagadish *et al*., 2007), cotton (Muthukrishnan and Balasubramanian, 1992) and potato (Prasannakumar *et al.,* 2012). In the present study, seasonal activity of *S. litura* has been monitored in castor using pheromone traps and found more number of moth catches during August to October. A similar trend in the *S. litura* moth catches was reported on soybean (Punithavalli *et al*., 2014; Syobu *et al*., 2003) and groundnut (Singh and Sachan, 1993). An ideal insect pest monitoring trap catch would always be directly proportional to the surrounding field population, so that trap catch provides a reliable estimate of insect pest density (Suckling, 2000). In the present study, high infestation of egg masses, larvae and per cent defoliation of *S. litura* found in the field during September to October and hence the moth catches too maximum during the period. Gedia *et al*. (2009), Prasannakumar *et al.* (2012) and Punithavalli *et al*. (2014) reported coincidence of moth catch in the pheromone traps with number of egg-masses, larval population and damage of *S. litura* on groundnut, potato and soybean, respectively. These results suggested that the moth catches in trap were indicative of the field incidence.

Relationship between pheromone trap catches and population and field damage of S. litura on castor : The correlation coefficients between pheromone trap catches of moths and oviposition, larval incidence and per cent defoliation of *S. litura* on castor for

the pooled data (*kharif*, 2012-13 to 2015-16) at Rajendranagar and Narkhoda are presented in Table 1. The correlation between current week and 1, 2 and 3 week after trap catches of moth found significantly and positively correlated with oviposition of *S. litura* on castor in both the locations (r = 0.598 to 0.855). Among all the periodicity, current week moth catches showed maximum correlation (r = 0.852 to 0.855) with oviposition as compared to different weeks after moths catches in trap (r = 0.598 to 0.749). The correlation between trap catches and larval population of *S. litura* on castor showed significant positive correlation with current week and different weeks after moth catches in trap (r = 0.712 to 0.873). Two week after moth catches in trap recorded strong correlation (r = 0.814 to 0.873) with incidence of larval population on castor. Similarly, there was a significant and positive association (r = 0.616 to 0.892) found between trap catches and per cent defoliation due to *S. litura* on castor in both the locations. However, three week after moth catches in trap recorded strong correlation (r = 0.868 to 0.892) with per cent defoliation in the field.

Correlation analysis established that the number of egg masses, larval populations and per cent

Table 1. Correlation coefficient (r) between the moth catches in the pheromone traps and oviposition, larval incidence and per cent defoliation of *S. litura* on castor (Pooled data of 2012-13 to 2015-16).

Parameters	Correlation values	
	Rajendra-nagar	Narkhoda
Oviposition		
Same week trap catches of moths	0.852**	0.855**
1-week after trap catches of moths	0.743**	0.648**
2-week after trap catches of moths	0.749**	0.598**
3-week after trap catches of moths	0.725**	0.672**
Larval incidence		
Same week trap catches of moths	0.712**	0.795**
1-week after trap catches of moths	0.855**	0.777**
2-week after trap catches of moths	0.873**	0.814**
3-week after trap catches of moths	0.788**	0.726**
Per cent defoliation		
Same week trap catches of moths	0.622**	0.616**
1-week after trap catches of moths	0.747**	0.776**
2-week after trap catches of moths	0.866**	0.891**
3-week after trap catches of moths	0.868**	0.892**

** = Correlation significant at the P<0.01 level of significance

Table 2. Relationship between pheromone trap catches of *Spodoptera litura* moths and per cent defoliation on castor.

Location and Year	Regression equation	R^2	Confidence interval		Predicted action threshold* (No. of moth catches/trap/week)
			Lower limit	Upper limit	
Rajendranagar					
2012-13	Y = -0.592 + 0.567X	0.748	0.425	0.708	96.7
2013-14	Y = -1.33 + 0.814X	0.569	0.509	1.120	59.8
2014-15	Y = -0.892 + 0.712X	0.636	0.480	0.944	58.1
2015-16	Y = -1.126 + 0.757X	0.688	0.537	0.977	62.1
Pooled data (2012-16)	Y = -0.893 + 0.677X	0.647	0.577	0.777	71.8
Narkhoda					
2012-13	Y = -1.191 + 0.734X	0.773	0.562	0.905	77.3
2013-14	Y = -1.073 + 0.717X	0.485	0.398	1.036	72.7
2014-15	Y = -0.172 + 0.523X	0.694	0.373	0.673	63.6
2015-16	Y = -0.287 + 0.505X	0.522	0.297	0.713	92.6
Pooled data (2012-16)	Y = -0.494 + 0.555X	0.561	0.456	0.653	89.5
Overall pooled data of 4 years and 2 locations	Y = -0.657 + 0.604X	0.595	0.534	0.674	81.4

(X = Mean moth catches/week; Y = Mean % defoliation)

defoliation of *S. litura* on castor significantly increased corresponding to the trap catches of male moths. Singh and Sachan (1993) and Sridhar *et al.* (1988) observed significant positive correlation between moth caught in pheromone traps and oviposition in soybean, groundnut, sugar beet and cauliflower. Punithavalli *et al*. (2014) found a positive correlation between the number of male moths captured in pheromone traps and numbers of egg masses and larvae in soybean. Prasannakumar *et al*. (2009) and Muthukrishnan and Balasubramanian (1992) revealed that the *S. litura* moth catches in pheromone traps were positively correlated with the feeding damage in potato and cotton. The results obtained in the present study are in consonance with those previous workers. The significant positive association observed between the trap catches of male moths and the field incidence of *S. litura* on castor has immense practical utility to forewarn the farmers to initiate management strategies.

Determination of an action threshold for S. litura based on pheromone trap catches : Among all the periodicity, significant and strong positive correlation found between three week after moth catches in trap and per cent defoliation due to *S. litura* on castor in both the locations. Hence, regression analysis was carried out with three week after moth catches in trap and per cent defoliation in the field due to *S. litura*. Regression analysis models along with coefficients of determinants between three week after moth catches in pheromone trap and per cent defoliation of *S. litura* during *kharif* 2012-13 to 2015-16 at two locations are presented in Table 2. Regression analysis revealed that the per cent defoliation in the field was a linear function of three week after moth catch in pheromone traps, indicating the possibility of assessing the level of damage from trap catches. Moth numbers in pheromone traps corresponding to more than 25% defoliation (grade 2) estimated from the regression equation ranged between 58.1 to 96.7 moths/trap/week and 63.6 to 92.6 moths/trap/week during four years of study at Rajendranagar and Narkhoda, respectively. Pooled analysis of the four years data indicated that moth numbers in pheromone traps corresponding to more than 25% defoliation was 71.76 and 89.45 moths/trap/week at Rajendranagar and Narkhoda, respectively. Overall pooled data of four years at two locations revealed that the pheromone trap catches corresponding to the economic threshold level of 25% defoliation of *S. litura* on castor was 81.4 moths/trap/week (Table 2).

The tobacco caterpillar, *S. litura* is the most destructive insect pest of castor and the yield losses are directly associated with increased defoliation. The castor crop could compensate 25% defoliation at any stage of the crop, but the yield reduction was significant beyond 25% (Lakshmamma *et al*., 2009). In the present study, regression analysis revealed that the per cent defoliation in castor was a linear function of three week after moth catch in pheromone traps, indicating the possibility of assessing the level of damage from trap catches. Earlier, Prasad *et al*. (1993), Kondo and Tanaka (1995), Bradley *et al*. (1998) and Walker *et al.* (2003) established control threshold for lepidopteran pests *viz*., *Helicoverpa armigera* in cotton, *Chilo suppressalis* in rice, *Epiphyas postvittana* in pipfruit and *Plutella xylostella* in vegetable Brassicas in terms of the pheromone trap catches, respectively. In the present study, pooled analysis of the four years data at two locations indicated that *S. litura* moth numbers in pheromone traps corresponding to more than 25% defoliation was 81.4 moths/trap/week. It is evident from this 4-year study that pheromone trap catches could be taken as an indicator of initiation of oviposition, larval population, defoliation of *S. litura* during *kharif* season and as a decision-making tool for adopting suitable management practices.

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