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Influence of abiotic factors on population dynamics of pink stem borer (*Sesamia inferens* Walker) in rice-wheat cropping system of India

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Abstract

Pink stem borer, *Sesamia inferens* (Lepidoptera: Noctuidae) (PSB) is originally a pest of rice but in recent past, it has also emerged as pest on wheat crop. Most of the studies in context to PSB seasonal abundance have been carried out on individual crops e.g. on rice, wheat or maize and only few reports are available on population dynamics of PSB throughout the year in rice-wheat cropping system. To meet this objective, seasonal abundance of PSB incidence was investigated on different host throughout the year during 2010-11 and 2011-12. The correlation between incidence of PSB and different abiotic factors *viz.* temperature, relative humidity and rainfall was also worked out. The results indicated that maximum incidence of PSB (2.76-4.17 %) was observed in the months of September-October during both the years when maximum, minimum and average temperature ranged from 31.9-33.9°C, 22.2-26.3°C and 26.9-29.5°C, respectively. Small peaks of PSB incidence were observed on wheat crop during the months of December and February. The values of correlation coefficient (r) between PSB incidence and maximum, minimum, average temperature and sunshine hrs were -0.19, -0.005 -0.11 and -0.27, respectively and they were non-significant at (p=0.05%). The incidence of *S. inferens* has statistically significant and positive correlation (r = 0.53) with relative humidity. Average relative humidity of 80 per cent was favourable for its damage. Similarly, a positive and non-significant correlation (r=0.15) of PSB incidence was recorded with rainfall.

Key words: *Sesamia inferens,* abiotic factors, seasonal dynamics, rice-wheat

1. Introduction

Pink stem borer, *Sesamia inferens* (PSB) is reported from all rice-wheat cropping systems but its severe damage was usually observed in lowland areas having staggered planting. The occurrence of *S. inferens* is worldwide. It has been widely observed in Bangladesh (Alam 1967), Thailand (King 1968), Indonesia (Soehardjan 1972), Philippines (Calora and Reyes 1972), India (Panda *et al*, 1976), China (Chiang 1977) and Pakistan (Inayatullah *et al* 1989). In the last two to three decades, the incidence of pink stem borer has been increasing in different Asian countries (Dhiman *et al* 1995, Palit 2001, Lina *et al* 2012).

PSB damage has been reported on rice, wheat, maize and sorghum crop (Atwal and Dhaliwal 1997). Earlier PSB has been causing economic damage to rice crop only but recently an increase in its damage on wheat and maize crop was observed (Ram *et al*., 2011, Singh and Kular, 2011, Singh *et al*., 2014, Pimentel and Peshin, 2014). The importance of this insect is increasing in rice-wheat cropping system of North-western plain of India because of mild winters and reduction in the time gap between harvesting of rice and sowing of wheat crop. The PSB has been carried from late sown rice to wheat crop in the month of November (Atwal and Dhaliwal 1997). The pinkish caterpillar of *S. inferens* bores into stem and kills central shoots forming 'dead hearts' (Deol, 2002). Garg (1988) reported that its larva remained dormant in winter and hibernated in rice stubbles from the end of October to March. During off-season the pest was also reported

on maize crop (Younis *et al.,* 1984; Rothschild 1971). The hibernating larva of PSB pupated in the first week of February and moths emerged in late February (Tripathi and Ram 1969). The pest was also carried from paddy to sugarcane crop in the months of November-December (Nagarkatti and Nair 1973).

Aboitic factors play an important role in the population build up insect pest. Most of the studies in context to PSB seasonal abundance have been carried out on individual crops e.g. on rice, wheat or maize and only few reports are available on population dynamics of PSB throughout the year in rice-wheat cropping system. Keeping in view the gap, the present studies have been formulated to find out the seasonal abundance and population build up of PSB on different host throughout the year.

2. Materials and methods

2.1 Correlation between PSB incidence and abiotic factors

The studies were carried at Experimental Area of Department of Plant Breeding and Genetics, PAU, Ludhiana during 2010-11 and 2011-12. The crops were grown as per recommendation of PAU, Package and Practices for *Rabi* and *Kharif* Crops (Anonymous, 2010). The rice and wheat crops were sown on June 22 and November 20, respectively during 2010-11 and June 20 and 23 November, respectively during 2011-12. The incidence of PSB was recorded on rice followed by wheat throughout the year by dissecting 10 randomly selected plants at fortnightly intervals. The incidence of PSB was also recorded from other crops (basmati rice, maize, jowar, sugarcane) grown in the vicinity of experiment. PSB cause damage by cutting the central shoot of the tiller and these damaged tillers are known as 'dead hearts'. Per cent damaged tillers were calculated by dividing the damaged tiller with total numbers of tillers per meter row length in wheat crop and then multiplying them with 100. In case of rice, it was calculated by dividing the damaged tiller with total number of tillers per hill and then multiplying them with 100. Visual observations to locate adults of PSB were also made. The PSB incidence was recorded from germination onwards and continued till crop maturity. The data on weather parameter viz. maximum, minimum, mean temperature, mean relative humidity, rainfall, evaporation, sunshine hours, wind velocity and mean vapour pressure were obtained from the Agro meteorological Observatory PAU, Ludhiana, India. The mean and simple correlation was calculated in order to find possible relationship of PSB damage and various meteorological factors.

2.2 Correlation between adult moth catch of PSB and abiotic factors

The light trap was used to record the presence of moths of PSB during different seasons throughout the year. An incandescent bulb of 100 Watt was fixed in pan downward position. The trap was in the centre of experimental area and operated from dusk to dawn. The light traps were examined at alternate day at 09.00-10.00 hrs and the average population count per fortnight was calculated for each month in 2011 and 2012. Throughout the trial, temperature, relative humidity, rainfall and lunar phase (Sunshine hrs) were obtained from the Meteorological Observatory, to investigate the influence of these factors on adult moth catches. The data were plotted separately against each weather parameter and correlation coefficients were also calculated for each weather parameter.

3. Results and discussion

3.1 Incidence and seasonal abundance of PSB in different crops

The data on incidence and seasonal abundance of PSB studied on different crops throughout the year during 2011 and 2012 is presented in Table 1. The data revealed that the pest was active on wheat crop in months of December and February-March during 2010-11. During this period, different stages of PSB were observed on wheat crop. Thereafter, some dead-hearts were seen on maize crop during the month of April. Thereafter, no incidence of PSB was observed on any crop until the second fortnight of July. Then slowly the stem borer damaged tillers again started appearing in rice crop and 2-3rd instar larvae were seen in the second fortnight of July 2011. Progressively the incidence of stem borer increased on rice crop from 0.48 per cent in second fortnight of July to 4.14 per cent in second fortnight of September during 2011. During this period, almost all developmental stages of PSBs were observed on rice crop. Thereafter, the pest damage started decreasing and it got shifted to *basmati* crop. The larvae and pupae of PSB were also observed in the stubbles of rice crop during the month of November 2011.

Thereafter, the incidence of pest shifted to wheat crop and it was mostly seen in larval stage (4-6th instar) during the month of December 2011. In the month of January 2012, a decrease in the incidence of pest attack was observed on wheat crop. It might be due to extreme cold conditions during which larva/pupa of PSB entered in arrested growth phase. Then a mild incidence of the pest was again witnessed during the second fortnight of February and March, 2012 (1.22-1.30 %). The pest attack shifted to maize crop in the months of March and April, 2012. Thereafter, the population of PSB decreased and again started building on rice crop in the months of July, 2012. The attack of PSB progressively increased and reached at its peak in the month of September-October 2012 (0.49-4.17 %) when the rice crop was at reproductive stage. Then, the pest shifted to *basmati* field and larvae and

Table 1. Prevalence and carryover of *S. inferens* in rice-wheat cropping system during 2010-11 and 2011-12

Month/ Fortnight	Crop	DH/WE/ Stubbles	Stage of insect	Damage (%)	Insects found
2010					
Nov II	Rice	-	-	-	
Dec I	Wheat	DH	3rd/4th Instar	2.15	PSB
Dec II	Wheat	DH	4th - 6th Instar/pupa	2.92	PSB
2011					
Jan I	Wheat	DH	4th - 6th Instar	0.90	PSB
Jan II	Wheat	-	-	0.00	
Feb I	Wheat	DH	Last instars/pupa	0.56	PSB
Feb II	Wheat	DH	2nd/ 3rd Instar	1.22	PSB
Mar I	Wheat	-	4th - last Instar	0.00	
Mar II	Wheat	WE	4th - 6th Instar	1.20	SF, PSB
April I	Wheat/maize	WE	2nd/ 3rd Instar	0.26	SF,PSB
April II	Wheat/maize	-	-	0.00	
May I	Maize	-	-	0.00	
May II	Maize	-	-	0.00	
June I	-	-	-	-	
June II	Rice	-	-	-	
July I	Rice	-	-	0.00	
July II	Rice	DH	2nd/ 3rd Instar	0.48	YSB
Aug I	Rice	DH	4th -5th instar	0.87	YSB+WSB
Aug II	Rice	DH	4th - last Instar	2.66	YSB+WSB
Sept I	Rice	DH	2nd/ 3rd Instar	3.23	PSB+WSB+YSB
Sept II	Rice	WE	2nd – last Instar	4.14	PSB+WSB+YSB
Oct I	Rice/*basmati*	WE	2nd to last Instar/pupae	3.28	PSB+WSB+YSB
Oct II	Rice/*basmati*	WE	All instar/pupa/adults	0.20	PSB+WSB+YSB
Nov I	Rice stubbles /*basmati*	-	Late instar/pupa/adults	0.00	
Nov II	Rice stubbles /*basmati*	-	Larva and pupa	0.00	
Dec I	Wheat	DH	4th/5th Instar	1.80	PSB
Dec II	Wheat	DH	4th/5th Instar /pupa	2.55	PSB
2012					
Jan I	Wheat	DH	4th –last instar	0.75	PSB
Jan II	Wheat	-	-	0.00	
Feb I	Wheat	DH	4th –last instar	0.48	PSB
Feb II	Wheat	DH	4th –last instar	1.30	SF,PSB
Mar I	Wheat	-	-	0.00	
Mar II	Wheat	WE	1st- 3rd Instar	1.22	SF,PSB
April I	Wheat/maize	WE	3rd -4th Instar	0.50	PSB
April II	Wheat/maize	-	-	0.00	
May I	Maize	-	-	0.00	
May II	Maize	-	-	0.00	
June I	Rice	-	-	0.00	
June II	Rice	-	-	0.00	
July I	Rice	DH	4th/5th Instar	0.49	YSB
July II	Rice	DH	4th/5th Instar	0.71	YSB+WSB
Aug I	Rice	DH	2nd/ 3rd Instar	0.96	YSB+WSB
Aug II	Rice	DH	2nd/ 3rd Instar	2.20	YSB+WSB
Sept I	Rice	DH	4th - 6th Instar	2.76	PSB+WSB+YSB
Sept II	Rice/*basmati*	WE	2nd – last Instar	4.17	PSB+WSB+YSB
Oct I	Rice/*basmati*	WE	2nd – last instar/pupae	3.04	PSB+WSB+YSB
Oct II	Rice stubbles /*basmati*	WE	All instar/pupa/adults	0.55	PSB+WSB+YSB

DH = Dead heart, WE = White ear, PSB = Pink stem borer, YSB = Yellow stem borer, WSB = White stem borer, SF = Shoot fly

pupae of PSBs were observed in the stubbles of rice crop during the month of November-December, 2012. Thus, it could be concluded that the pest was active throughout the year on different crops *viz.* rice, *basmati* rice, wheat and maize throughout the year. A small period of arrested growth was observed in the month of January on wheat and May-June on rice crop.

3.2 Correlation between PSB incidence and abiotic factors

Maximum incidence of PSB was observed in the months of September-October on rice crop when maximum, minimum and average temperature ranged from 31.9-33.9°C, 22.2-26.3°C and 26.9-29.5°C, respectively (Fig. 2). Small peaks of PSB incidence were also observed on wheat crop during the months of December and February. However, no or little incidence of PSB was observed in the month of January when the average temperature (9.4-14.2°C) dips below the lower developmental threshold of 15°C as reported by Rahman and Khalequzzaman (2004). A weak negative correlation was observed between the incidence of PSB and temperature. The values of correlation coefficient with maximum, minimum and average temperature were -0.19, -0.005 and -0.11 respectively and they were non-significant at (p=0.05%). The present investigations are in agreement with (Joshi *et al*., 2009).

The incidence of *S. inferens* has statistically significant and positive correlation (r = 0.53) with relative humidity (Fig. 3). The maximum incidence of PSB was observed on matured rice crop in the month of September when the average relative humidity was above 80 per cent (84-85.5 %). Thereafter the incidence of PSB decreased

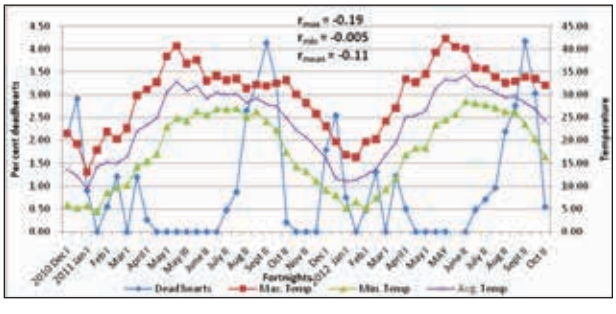
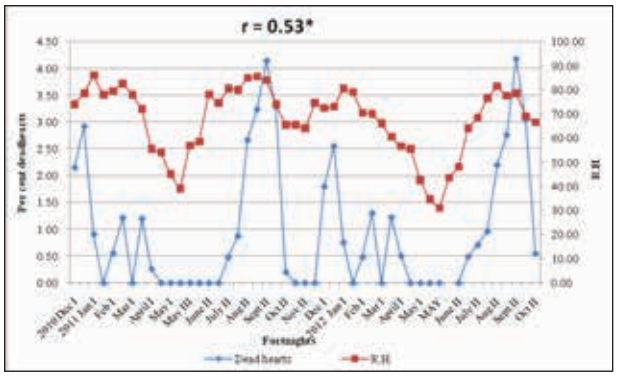


Fig. 2: Incidence of *S. inferens* in relation to temperature

with the decrease in relative humidity (65-74.5 %) up to the first fortnight of December. Again, a small increase in PSB incidence (2.92 %) was observed on wheat crop with increase in relative humidity (86 %) during the second fortnight of December and first week of January. The present investigation revealed that relative humidity of 80 or above was favourable for the development of PSB. However, Joshi *et al.* (2009) reported a negative correlation between relative humidity and PSB incidence.



** = Significant at 5% level*

Fig. 3: Incidence of *S. inferens* in relation to relative humidity

A positive and non-significant correlation (r=0.15) was observed between rainfall and PSB incidence. The 30-60 mm rainfall during the month of September was highly favourable for the population build up of PSB in rice (Fig. 4). In wheat crop, the rainfall did not play any role in PSB incidence as very little rainfall has been witnessed during the months of December-January when the pest appeared on wheat crop. (Rehman *et al.,* 2002) reported that rainfall in the months of July-October favoured the outbreak of stem borer in rice crop which is in agreement with present investigations.

There was negative correlation and non-significant (r= -0.27) between incidence of PSB and sunshine hrs (Fig. 5). In 2011, the higher incidence of PSB was observed in the months of December-January on wheat and September

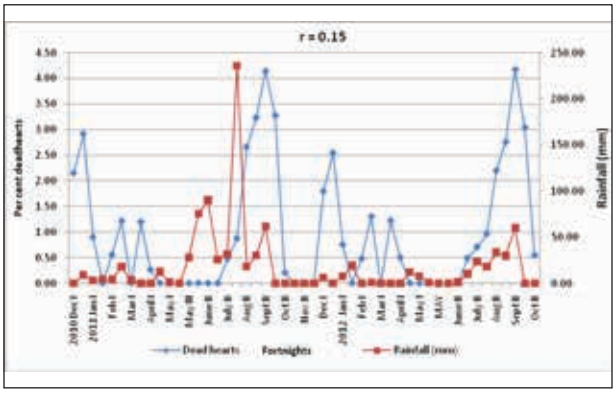


Fig. 4: Incidence of *S. inferens* in relation to rainfall (mm)

on rice when sunshine hrs (2.55-7.45) was quite small. But during 2012, the sunshine hrs (5.15-9.08) was quite longer during the peak period of activity of PSB. Overall, it was noticed whenever there was decrease in sunshine hrs, an increase in PSB incidence was observed.

3.3 Correlation between adult moth of PSB and abiotic factors

The adults were very difficult to locate in the field during day period. Occasionally, they were found sitting at base

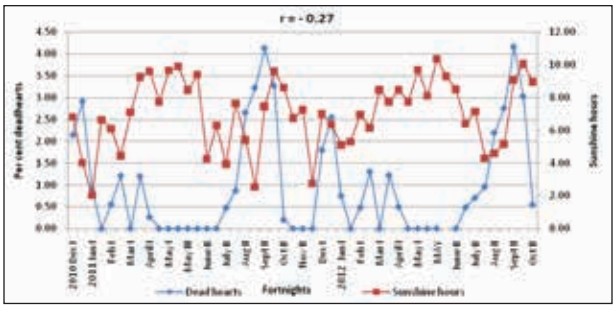


Fig. 5: Incidence of *S. inferens* in relation to sunshine hrs

of plant near soil level or even on soil surface and never found over the foliage of wheat/rice crop. Therefore, sweep netting could not provide enough adult moth-catch. No doubt, some adults were captured in light traps, but it has been observed that the adults of PSB were not attracted strongly towards such light traps. A maximum of 4-5 adults were captured/fortnight during the months of September-October which did not depict the original picture of PSB incidence observed in the field conditions. The damage observed in the field was much more as compared to the adults captured in the light traps. When the moth catch data were correlated with different weather parameters, it was non-significant for all the weather parameters. The values of correlation coefficient (r) with different weather parameters were 0.08, 0.12, 0.10, 0.29, -0.02, 0.15 for maximum temperature, minimum temperature, mean temperature, average relative humidity, rainfall and sunshine hrs, respectively (Fig. 6-9). No consistent seasonal abundance pattern of PSB was available in relation to light trap studies. However positive correlation of noctuid moth catch with temperature (Holyoak *et al.,* 1997), sunshine hrs (Sharma *et al*., 2002) and negative correlation with rainfall (Pandey *et al*., 2001) has been reported.

Overall correlation study of PSB incidence showed positive correlation (r=0.15) with rainfall in the months of September and this rainfall resulted in an increase relative humidity in subsequent days. The relative humidity was the only abiotic factor which has significant and positive correlation (r = 0.53) with the incidence of PSB while

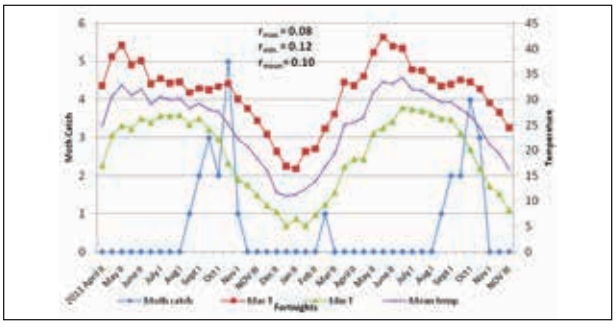


Fig. 6: Relationship between moth catch of *S. inferens* (light trap) and temperature

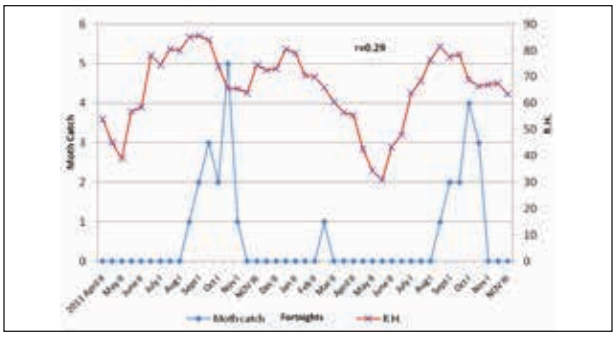


Fig. 7: Relationship between moth catch of *S. inferens* (light trap) and relative humidity

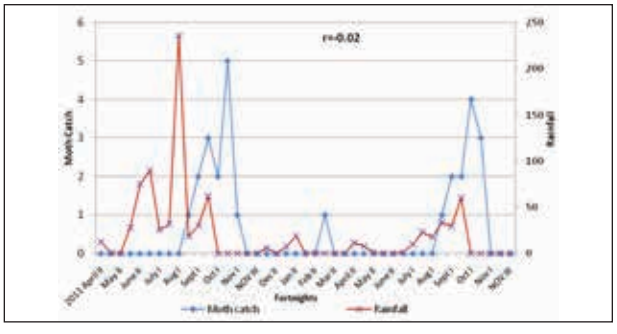


Fig. 8: Relationship between moth catch of *S. inferens* (light trap) and rainfall (mm)

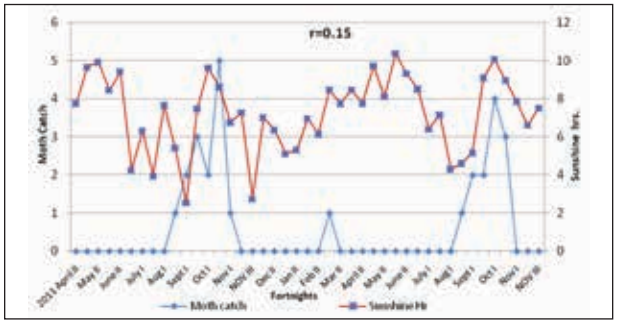


Fig. 9: Relationship between moth catch of S. inferens (light trap) and sunshine hrs

all other abiotic factors has non-significant relationship. Average relative humidity of 80 per cent was highly favourable for its incidence. The information generated from the present studies can be used for management of PSB damage through appropriate timing of insecticide application in rice crop and if it could be properly managed on rice crop in the month September, it will not cause much damage to succeeding wheat crop.

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