Population dynamics of pink stem borer, *Sesamia inferens* (Walker) on maize as influenced by weather conditions

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Abstract: A field study on population dynamics of pink stem borer, *Sesamia inferens* (Walker) on maize was carried out during *rabi*, 2015-2016 at the research farm of CCS Haryana Agricultural University, Regional Research Station, Karnal. Studies on population dynamics revealed that the maximum number of egg masses was observed during 46th SW (standard week), 2015. The larval population increased after 45th SW and reached the maximum during the 49th SW, 2015 and then declined till 7th SW, 2016. Maximum plant infestation by larvae was recorded 19.5 per cent in inbred HKI 1128 and 21.0 per cent in hybrid HQPM 1 during the 7th SW, 2016. No larval activity of *S. inferens*, plant infestation and dead hearts were observed during 2nd SW to 4th SW of 2016 (second week to last week of January). It could be due to the fact that insect might have entered the hibernation. Correlation of *S. inferens* population with various environmental factors revealed that larval population had a significant negative correlation with maximum temperature (Tmax.) and minimum temperature (Tmin.), rainfall (RF) (r= -0.4992, -0.5183 and -0.5698) on HKI 1128 and (r= -0.4872, -0.4717 and -0.5242) on HQPM 1, respectively. Multiple regression analysis of *S. inferens* population with weather parameters showed that there was 80 per cent (HQPM1) and 82 per cent (HKI 1128) variability in larval population due to various environmental factors. The population dynamics revealed by this study have far reaching significance in pest management strategy as integrated control measures may be focused only during the period wherein population exceeds economic threshold level (ETL).

Keywords: Population dynamics, *Sesamia inferens*, Maize, Weather conditions

INTRODUCTION

Maize (*Zea mays* L.) is one of the most important cereal crops of the world and contributes to food security in most of the developing countries. It is cultivated over a range of agro climatic zones and the suitability of maize to diverse environments is unmatched by any other crop. It is grown in more than 150 countries but the major producing countries are USA, China, Brazil, Mexico, France and India. It can be used at any stage of its growth and has over three thousand industrial uses. In India, maize is cultivated throughout the year in all states of the country for various purposes including grain, fodder, green cobs, sweet corn, baby corn and popcorn. Maize is important in human nutrition and also used as animal feed. It can be cultivated throughout the year in different seasons (*kharif, rabi and spring*) in one or the other part of the country. The demand of the maize is increasing every day due to expansion of maize based industries. It is third important cereal crop in India after rice and wheat and occupies an area of 8.78 million hectares having production of 21.76 million tones with average productivity of 2.48 t/ha (Anonymous, 2014). The average productivity is very low in comparison to its potential. Since the gap between the productivity and the poten-

tial is very wide, there is tremendous scope for the management of crop production/ protection practices.

Pink stem borer, *S. inferens* is one of the major insect pests of maize next to *Chilo partellus*. *S. inferens* is a serious pest of maize in India, Pakistan, Bangladesh, Burma, China, Sri Lanka, Malaysia, Taiwan, Japan, Indonesia, and the Philippines (Teetes *et al.,* 1983). In India, it is a major pest in Andra Pradesh, Karnatka, Tamil Nadu, Maharastra, Uttar Pradesh, Assam, Bihar, Delhi, Punjab, Orrisa, Madhya Pradesh, West Bengal and Andaman and Nicobar (Rajagopal and Channabasavanna, 1975; Bhattacharya, 1976; Sajjan *et al.,* 1986; Upadhyaya *et al,* 1991). Recently, *S. inferens* has emerged as a new pest and is likely to pose serious threat to the successful cultivation of maize in the north-western plains of India under largely adopted rice-wheat/maize cropping system (Singh and Kular, 2015). It attacks and damages every part of maize except root. Yield loss is mainly due to dead heart formation in maize crop (Siddiqui and Marwaha, 1993). In India, the losses due to pink stem borer on maize are reported to be varied from 25.7 to 78.9 percent (Chatterji *et al.,* 1969) and 25 to 80 per cent (Rao *et al.,* 1983). *S. inferens* is an emerging pest in Haryana and causes economic damage to the production of maize during *rabi* season. It is a polyphagous pest and

a considerable population of this pest migrates from paddy and wheat crops to winter maize. The incidence of *S. inferens* is on an increasing trend and may be a threat to winter maize cultivation. A thorough knowledge of population dynamics in relation to biotic, abiotic factors of an insect-pest is essential for developing efficient pest management strategies. The information on population dynamics of any insect pest in a given ecological niche should be considered as starting point for evolving eco- friendly pest management strategies. It is an established fact that population dynamics of any insect is greatly influenced by weather fluctuations and thereby the location specific studies become more imperative. It was with this in mind that the present study was carried out to investigate population dynamics of pink stem borer, *S. inferens* on maize as influenced by weather conditions.

MATERIALS AND METHODS

This study pertaining to population dynamics of pink stem borer, *Sesamia inferens* (Walker) on maize was carried out during *rabi*, 2015-2016 at research area of CCS Haryana Agricultural University, Regional Research Station, Karnal, Haryana. To study the population fluctuation of pink stem borer during *rabi* 2015-16, maize inbred (HKI 1128) and hybrid (HQPM 1) were planted in a plot size of 20 x 20 m with a spacing of 70 x 20 cm in a randomized block design in three replications. None of the insecticide was sprayed and all other recommended agronomic practices were followed to raise the crop. Different stages of the pink stem borer (egg and different post embryonic development stages) were recorded at 7 days interval from October, 2015 to April, 2016. Observations were recorded from 20 plants uprooted from two rows of 2.5 m at 7 days interval. The observations were started 5 days after germination (DAG) of the crop. The sample were uprooted and brought to lab and dissected on the same day. Each stem was split open longitudinally from base to tip or vice-versa for recording different stages of the stem borer. Observations on infested plants and dead heart formation were also recorded.

Data on weather parameter such as temperature, relative humidity, sunshine hours and rainfall was obtained from meteorological observatory of Central Soil Salinity Research Institute (CSSRI), Karnal, Haryana. Correlations and regression analysis between *S. inferens* populations at different observation periods with different meteorological parameters were worked out using SPSS 16.0 version. The results have been discussed and interpreted in relation to the likely impact of weather parameters.

RESULTS AND DISCUSSION

Population dynamics: The results of the present investigations on population dynamics of pink stem borer, *S. inferens* on winter maize indicate that the moths
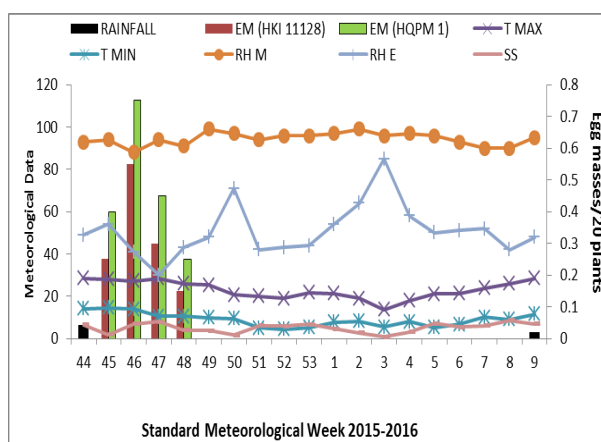

Fig. 1. *Number of egg masses of S. inferens in relation to environmental factors during different standard weeks on maize genotypes (HKI 1128 and HQPM 1).*
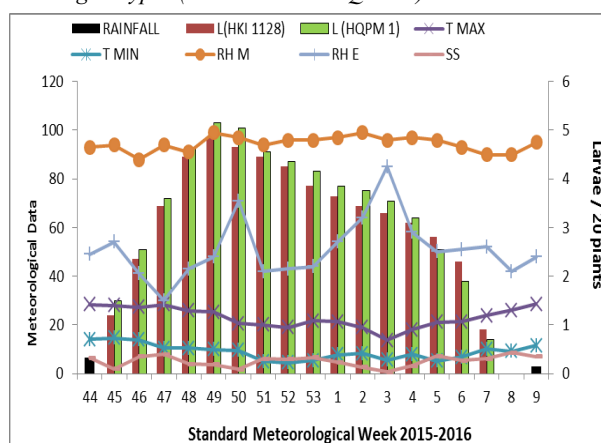

Fig. 2. *Population of larvae of S. inferens in relation to environmental factors during different standard weeks on maize genotypes (HKI 1128 and HQPM 1).*

of *S. inferens* started egg laying in the field during 45th SW and continued to 48th SW (first to last week of November). The number of egg masses during the 45th SW (first week of November) was low i.e. 0.25 egg masses/ 20 plants in HKI 1128 and 0.40/20 masses/20 plants in HQPM 1(Fig.1). During the 46th SW, number of egg masses laid by females of *S. inferens* increased and reached to 0.55 and 0.75 egg masses/ 20 plants in HKI 1128 and HQPM 1, respectively. After this peak, a declining trend in density of egg masses per 20 plants was observed during 47th and 48th SW i.e. 0.30 and 0.15 egg masses/ 20 plants on HKI 1128 and 0.45 and 0.25 egg masses/ 20 plants on HQPM 1, respectively. No egg masses was observed during 49th SW and afterwards. Average number of egg masses was observed low in HKI 1128 as compared to HQPM 1 (Fig. 1).

No information is available on the correlation of egg masses of *S. inferens* and environmental factors in the literature. However, Joshi *et al.* (2009) reported that number of egg masses decreases with decrease in temperature in rice. Joshi *et al.* (2009) also reported that
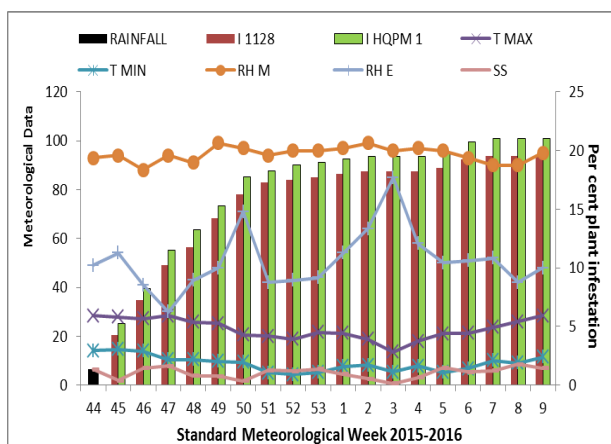
Fig. 3. *Per cent plant infestation by Sesamia inferens in relation to environmental factors during different standard weeks on maize genotypes (HKI 1128 and HQPM 1).*
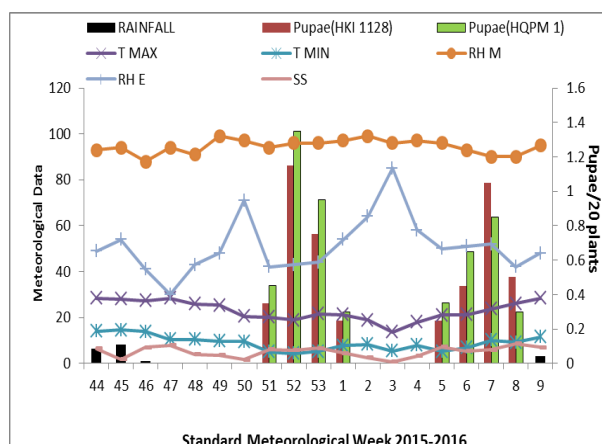

Fig. 4. *Per cent dead heart formation by Sesamia inferens in relation to environmental factors during different standard weeks on maize genotypes (HKI 1128 and HQPM 1)*

Fig. 5. *Population of pupae of Sesamia inferens in relation to environmental factors during different standard weeks on maize genotypes (HKI 1128 and HQPM 1).*
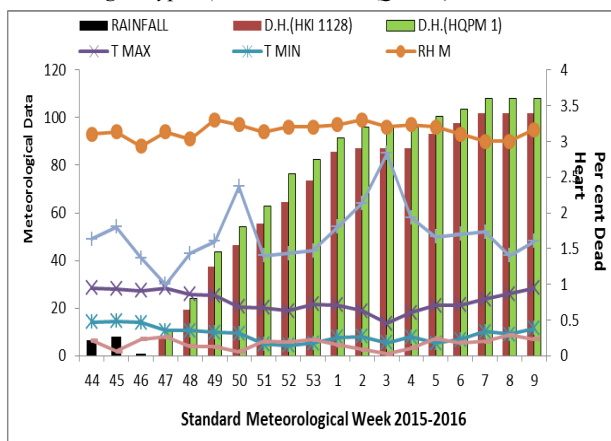
number of egg masses started decreasing from second and third week of October in rice and no egg masses was observed during fourth week of October and first week of November. However, in present studies the moths of *S. inferens* started egg laying in the maize field during first week of November and continued up to last week of November. It could be due to the factor that in rice adult female moth did not laid eggs as the crop stage was at maturity and pest might have migrated to wheat and winter maize.

Larval population of *S. inferens* on maize (Fig. 2) was reported from 45th SW, 2015 to 7th SW, 2016 (last week of October to first week of March). The larval density varied from 0 to 4.85/20 plants on HKI 1128 and 0 to 5.15/20 plants on HQPM 1 from 44th SW, 2015 to 9th SW, 2016 (last week of October to first week of March). The average number of larvae was low in HKI 1128 as compared to HQPM 1. The average number of larvae was low i.e. 1.2/ 20 plants in HKI 1128 and 1.5/20 plants on HQPM 1 during 45th SW, 2015 (first week of November). Thereafter, the larval population increased gradually and reached to

maximum of 4.85/ 20 plants on HKI 1128 and 5.15/ 20 plants on HQPM 1 during the 49th SW, 2015. After this SW, number of larvae started decreasing. However, during the 2nd, 3th and 4th SW of 2016 larvae were not found infesting the crop because of the reason that it entered the hibernation. They were found singly or in groups in plant stem and dead hearts of maize. Diapause occurred in the sixth instar was facultative, induced by decrease in temperature. After 4th SW (last week of January), number of larvae started decreasing till 9th SW of 2016 in both maize genotypes i.e. HKI 1128 and HQPM 1 (Fig. 2). The data indicate that the maximum larval population was occurred during last week of November and first week of December, afterwards average larval population decreased (Fig. 2). The infestation by *S. inferens* varied from 0 to 19.5 per cent in HKI 1128 and 0 to 21 per cent (Fig. 3) during 45th SW, 2015 to 6th SW, 2016 (last week of October to second week of February). The average dead heart formation by pink stem borer varied from 0 to 3.4 per cent in HKI 1128 and 0 to 3.6 per cent (Fig. 4) during 45th SW, 2015 to 6th SW, 2016 (last week of October to second week of February).No larval activity, per cent infestation and dead hearts of *S. inferens* was observed on maize during 2th SW to 4th SW of 2016 (Second week to last week of January). It could be due to the fact that insect might have entered the diapause (hibernation). No systematic information is available in literature regarding influence of weather parameters on incidence of *S. inferens*. However, Singh and Kular (2015) observed short peaks of *S. inferens* incidence on wheat crop during the months of December and February. Rahman and Khalequzzaman (2004) reported that *S. inferens* have the lower developmental threshold below 15°C because of which larval incidence decreased or no incidence was there. However, Garg (1988) reported that larvae of *S. inferens* remained dormant in winter and hibernated in rice stubbles from the end of October to March.

Table 1. Correlation of *Sesamia inferens* population with environmental factors on maize genotypes (HQPM 1 and HKI 1128).

Weather parameter	Egg masses	Larvae	Pupae	Infested plants	Dead Hearts
HKI 1128					
Temperature (maximum)	0.4980*	-0.4992*	-0.2132	-0.6060*	-0.5455*
Temperature (minimum)	0.5763*	-0.5183*	-0.4796*	-0.7531*	-0.6353*
Relative humidity (%) M	-0.5317*	0.5042*	-0.1875	0.2996	0.2438
Relative humidity (%) E	-0.3753	0.0974	-0.2503	0.2388	0.3207
Sun shine hours	0.1534	-0.3889	0.3723	0.0058	0.0544
Rainfall (mm)	0.2307	-0.5698*	-0.2996	-0.7465*	-0.5114*
HQPM 1					
Temperature (maximum)	0.5150*	-0.4872*	-0.2851	-0.5940*	-0.5781*
Temperature (minimum)	0.5890*	-0.4717*	-0.5781*	-0.7412*	-0.6690*
Relative humidity (%) M	-0.5249*	0.5202*	-0.0678	0.2858	0.2746
Relative humidity (%) E	-0.3805	0.1343	-0.2556	0.2338	0.3280
Sun shine hours	0.1318	-0.4377	0.3386	0.0021	0.0361
Rainfall (mm)	0.2594	-0.5242*	-0.3018	-0.7480*	-0.5357*

*Significant at P = 0.05

Table 2. Multiple regression analysis between *Sesamia inferens* population and environmental factors on maize genotypes (HQPM 1 and HKI 1128).

HKI 1128	Regression equations	R^2
EGG MASSES	$Y5 = 5.145 - 0.077 X1 + 0.121 X2 - 0.031 X3 - 0.033 X4 - 0.033 X5 - 0.006 X6$	0.59
LARVAE	$Y2 = 3.781 - 0.041 X1 - 0.072 X2 + 0.116 X3 - 0.124 X4 - 0.735 X5 - 0.348 X6$	0.82
PUPAE	$Y4 = 6.079 - 0.007 X1 - 0.093 X2 - 0.049 X3 - 0.005 X4 + 0.017 X5 + 0.037 X6$	0.48
INFESTED PLANTS	$Y1 = -2.451 + 0.198 X1 - 0.315 X2 + 0.003 X3 + 0.064 X4 + 0.084 X5 - 0.248 X6$	0.75
DEAD HEART	$Y3 = -7.369 + 0.151 X1 - 0.289 X2 + 0.014 X3 + 0.107 X4 + 0.361 X5 - 0.108 X6$	0.65
HQPM 1		
EGG MASSES	$Y10 = 5.987 - 0.075 X1 + 0.122 X2 - 0.037 X3 - 0.026 X4 - 0.059 X5 - 0.0018 X6$	0.61
LARVAE	$Y7 = 2.612 - 0.0513 X1 - 0.0414 X2 + 0.136 X3 - 0.131 X4 - 0.797 X5 - 0.361 X6$	0.80
PUPAE	$Y9 = 6.201 - 0.015 X1 - 0.1145 X2 - 0.0425 X3 - 0118 X4 + 0.004 X5 + 0.0612 X6$	0.58
INFESTED PLANTS	$Y6 = -1.781 + 0.223 X1 - 0.341 X2 - 0.0059 X3 + 0.0672 X4 + 0.064 X5 - 0.269 X6$	0.74
DEAD HEART	$Y8 = -7.759 + 0.148 X1 - 0.309 X2 + 0.022 X3 + 0.1077 X4 + 0.363 X5 - 0.118 X6$	0.67

X1 = Temperature (maximum), X2 = Temperature (minimum), X3 = Relative humidity (morning), X4 = Relative humidity (evening), X5 = Sun shine hours, X6 = Rainfall (mm)

The data on pupal density indicate that there were two peaks of population of pupae i.e. one during 52nd SW and the second during 7th SW. The pupal density varied from 0 to 1.15/20 plants on HKI 1128 and 0 to 1.35/20 plants from 44th SW, 2015 to 9th SW, 2016 (last week of October to first week of March). The average number of pupae was low in HKI 1128 as compared to HQPM 1 (Fig. 5). The larvae reached near maturity and changed to pupae in the 51st SW of 2015. Thereafter, the population of pupae increased and reached to maximum of 1.15/ 20 plants on HKI 1128 and 1.35/ 20 plants in HQPM 1 during the 52th SW, 2015. After this, number of pupae started decreasing till 1st SW of 2016. However, during the 2th, 3th and 4th SW of 2016 pupae were not found in the crop (HKI 1128 and HQPM 1) because of the reason that larvae entered the hibernation. The number of pupae started increasing again from 5th SW of 2016 in both maize genotypes (HKI 1128 and HQPM 1). Thereafter, the population of pupae increased gradually and reached to 1.05/ 20 plants in HKI 1128 and 0.85/ 20 plants in HQPM 1 during the 7th SW, 2016 (Fig. 5). After this period of observation, number of pupae started decreasing and no pupae observed during on 9th SW of 2016 in both maize genotypes (HKI 1128 and

HQPM 1). The data indicate that there were two peaks of population of pupae during *rabi* maize. Tripathi and Ram (1969) reported that the hibernating larva of pink stem borer pupated in the first week of February and moths emerged in late February give support to the present findings.

Impact of weather on pest activity: Different environmental variables seemed to affect *S. inferens* population in different ways. *S. inferens* egg masses had a significant positive correlation with maximum temperature (Tmax.) and minimum temperature (Tmin.) and had a significant negative correlation with Relative humidity (Morning) (RHm) (r= 0.4980, 0.5763 and -0.5317) on HKI 1128 and (r= 0.5150, 0.5890 and -0.5249) on HQPM 1, respectively (Table 1). No information is available on the correlation of egg masses of *S. inferens* and environmental factors in the literature. However, Joshi *et al.* (2009) reported that number of egg masses decreases with decrease in temperature in rice. The larvae of *S. inferens* was correlated with abiotic factors (meteorological) it was found that larval population had a significant negative correlation with maximum temperature (Tmax.) and minimum temperature (Tmin.) (r= -0.4992, -0.5183) on HKI 1128 and (r= -0.4872, -0.4717) on HQPM 1, respectively (Table 2).

Joshi *et al.* (2009) reported a significant negative correlation with maximum and minimum temperatures (r values = -0.543 and -0.878). However, Singh and Kular (2015) reported negative correlation was observed between the incidence of pink stem borer and maximum temperature and minimum temperature (r values = -0.19 and -0.005). The larval population of *S. inferens* in the present investigations, had a significant positive correlation with Relative humidity (Morning) (RHm) (r=0.5042) on HKI 1128 and (r=0.5202) on HQPM 1 (Table 1). Likewise, positive effect of relative humidity (r = 0.53) on population build up of this pest has been reported by Singh and Kular (2015).

In the present investigations, the pest had significant negative correlation with rainfall (r= -0.5698 on HKI 1128 andr= -0.5242 on HQPM 1). Likewise, negative effect of rainfall on population buildup of this pest has been reported by Bhatnagar and Saxena (1999) and Rai *et al.* (2002). However, Isahaque and Rahman (1983) reported positive effect of rainfall on population buildup of this pest. In the present studies, data on larvae of *S. inferens* was correlated with sun shine hours (SSH) it was found that larval population had a negative correlation with sun shine hours (SSH) and rainfall (RF) (r= -0.3889) on HKI 1128 and (r= -0.4377) on HQPM 1, respectively. However, Isahaque and Rahman (1983) did not find any effect of sunshine hours on the population of borers.

In the present studies, a significant negative correlation between pupae and minimum temperature (Tmin.) (r= -0.4796 on HKI 1128 andr= -0.5781 on HQPM 1) was observed. However literature is silent, on the correlation of population of pupae of *S. inferens* and environmental factors. It was further observed in the present studies that a significant negative correlation was worked out between per cent infested plants and maximum temperature (Tmax.) and minimum temperature (Tmin.), rainfall (RF) (r= -0.6060, -0.7531 and -0.7465) on HKI 1128 and (r= -0.5940, -0.7412 and -0.7480) on HQPM 1, respectively. There was also significant negative correlation between dead hearts and maximum temperature (Tmax.) and minimum temperature (Tmin.), rainfall (RF) (r= -0.5455, -0.6353 and -0.5114) on HKI 1128 and (r= -0.5781, -0.6690 and -0.5357) on HQPM 1, respectively. No information is available in literature on the correlation of pupae and dead hearts of *S. inferens* and environmental factors.

Multiple regression analysis: The multiple regression analysis, which explained the average relationship between *S. inferens* and weather parameter *i.e.* the trend of changes in *S. inferens* population per unit change in weather parameters, indicated that there was also significant 59 per cent and 61 per cent (regression equation Y1 and Y6) contribution of these factors (R^2 = 0.59 in HKI 1128 and R^2= 0.61 in HQPM 1) for variability in egg masses (Table 2). Out of 59 per cent (HKI 1128) and 61 per cent (HQPM1) variability in pink

stem borer egg masses due to various abiotic factors, maximum temperature (Tmax.) and minimum temperature (Tmin.), relative humidity (morning) accounted for 46 per cent (HKI 1128) and 45 per cent (HQPM 1) variability (regression equation – Y1 and Y6) and these were the most important factors affecting egg masses. There was also significant 75 per cent and 74 per cent (regression equation Y2 and Y7) contribution of these factors (R^2 = 0.82 in HKI 1128 and R^2= 0.80 in HQPM 1) for variability in larval population (Table 2). Out of 82 per cent (HKI 1128) and 80 per cent (HQPM1) variability in pink stem borer larval population due to various abiotic factors, maximum temperature (Tmax.) and minimum temperature (Tmin.), rainfall (RF), relative humidity (morning) accounted for 51 per cent (HKI 1128) and 48 per cent (HQPM 1) variability (regression equation-Y2 and Y7) and these were the most important factors affecting pink stem borer abundance (Table 2).

It was found that for total variability in pupae contribution by abiotic factors (meteorological) was 48 per cent and 58 per cent (regression equation Y3 and Y8) (R^2 = 0.48 in HKI 1128 and R^2= 0.58 in HQPM 1) (Table 2). Out of 48 per cent (HKI 1128) and 58 per cent (HQPM1) variability in pink stem borer pupae due to various abiotic factors, minimum temperature (Tmin.) accounted for 22 per cent (HKI 1128) and 33 per cent (HQPM 1) variability (regression equation – Y3 and Y8) and these were the most important factors affecting pupae.

There was also significant 75 per cent and 74 per cent (regression equation Y4 and Y9) contribution of these factors (R^2 = 0.75 in HKI 1128 and R^2= 0.74 in HQPM 1) for variability in per cent infested plants (Table 2). Out of 75 per cent (HKI 1128) and 74 per cent (HQPM1) variability in per cent infested plants due to various abiotic factors, maximum temperature (Tmax.) and minimum temperature (Tmin.), relative humidity (morning) accounted for 66 per cent (HKI 1128) and 65 per cent (HQPM 1) variability (regression equation – Y4 and Y9) and these were the most important factors affecting per cent infested plants. There was also significant 65 per cent and 67 per cent (regression equation Y5 and Y10) contribution of these factors (R^2 = 0.65 in HKI 1128 and R^2= 0.67 in HQPM 1) for variability in dead hearts (Table 2). Out of 65 per cent (HKI 1128) and 67 per cent (HQPM1) variability in pink stem borer dead hearts due to various abiotic factors, maximum temperature (Tmax.) and minimum temperature (Tmin.), relative humidity (morning) accounted for 41 per cent (HKI 1128) and 46 per cent (HQPM 1) variability (regression equation – Y5 and Y10) and these were the most important factors affecting dead hearts. Joshi *et al.* (2009) reported that density of egg masses declined after with decrease in temperature and a negative correlation of the total larvae with maximum temperature, minimum temperature

and evening relative humidity and a positive correlation was observed between the mortality of larvae and maximum temperature, sunshine hours while it was negative with morning relative humidity. Velasco *et al.* (2007) also reported that there is a clear relationship between altitude of locality and abundance of the borer. Population of the borer has a significant relationship with the temperature parameters.

This study generated valuable data on the population dynamics of this pest which is one of the most important pests of maize. The data so generated would help in the forecast about it likely incidence on the basis of prevailing weather and shall also prove helpful in devising a coherent strategy for its management.

Conclusion

The information on population dynamics of any insect pest in a given ecological niche should be considered as starting point for evolving eco- friendly pest management package. It is an established fact that population dynamics of any insect is greatly influenced by weather fluctuations and thereby the location specific studies become more imperative. Although study of population dynamics of this study were conducted elsewhere but this is first study of its kind in the state of Haryana. The number of egg masses laid by females of *S. inferens* increased and reached to 0.55 and 0.75 egg masses/ 20 plants during the 46th SW, in HKI 1128 and HQPM 1, respectively. The larval density varied from 0 to 4.85/20 plants on HKI 1128 and 0 to 5.15/20 plants on HQPM 1 from 44th SW, 2015 to 9th SW, 2016 (last week of October to first week of March). No larval activity, per cent infestation and dead hearts of *S. inferens* was observed on maize during 2th SW to 4th SW of 2016 (Second week to last week of January). It could be due to the fact that insect might have entered the diapause (hibernation). The population dynamics revealed by this study has far reaching significance in pest management strategy as integrated control measures may be focused only during the period wherein population exceeds economic threshold level (ETL).

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