Pakistan J. Zool., vol. 43(5), pp. 863-868, 2011.

Impact of Abiotic Factors on Incidence of Fruit and Shoot Infestation of Spotted Bollworms *Earias* spp. on Okra (*Abelmoschus esculentus* L.)

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Abstract.- Role of weather factors on the fluctuations of fruit and shoot infestation by *Earias* spp. on three comparatively more susceptible (Parbani Karanti, Pusa sawani, Ikra-1), three moderately susceptible (PMS-beauty, Ikra anamika, Lakshami-24) and three comparatively least susceptible (Diksa, Sabz ari, Super Star) genotypes of okra was studied under field conditions at Post Graduate Agriculture Research Station, University of Agriculture Faisalabad, during 2006 and 2007. Maximum, minimum and average temperatures showed a positive effect; whereas, the relative humidity and rainfall exerted a negative effect on the fruit infestation, separately as well as on cumulative basis. The shoot infestation of okra was found to be positively correlated with maximum and average temperatures and negatively correlated with the relative humidity and rainfall on the basis of an average for both the years of studies. Multiple Linear Regression Models revealed that the maximum temperature was the most important factor, which had maximum impact on fruit and shoot infestation, *i.e.*, 60.50 and 53.20% for an average of both the study years, respectively. The impact of all the factors on an average of both the study years when computed together was found to be 67 and 55.50%, for fruit and shoot infestation, respectively.

Keywords: Okra, spotted bollworms, weather factors, shoot and fruit infestation.

INTRODUCTION

Okra (*Abelmoschus esculentus* L.) is a warm season annual crop of the family Malvaceae and is one of the most common vegetables grown in Pakistan. It is cultivated almost throughout the year except for one or two cold months, due to favorable climatic conditions for its cultivation (Memon *et al*., 2004). It was cultivated on 14,996 hectare area with 103659 tonnes production during 2007 (GOP, 2008). Okra is a very useful plant. It is mainly cultivated for edible fruits but its other parts like leaves, flower petals, stems and roots are also being used as a food, bio-fuel and as a medicine in different parts of the world. Okra fruits have nutritious as well as dietary value. Its nutritive value is higher than tomatoes, eggplant and most cucurbits except bitter gourds (Nonnecke, 1989). The seeds of okra fruits are rich in protein (Martin, 1982) and their mucilage contains different medicinal properties (Benjamin *et al*., 1951).

Okra is attacked by a number of insect pests, but spotted bollworms are among the most important of them (Gulati, 2004). The damage to the crop is done by two ways. First, the terminal portions of growing shoots are bored by the caterpillars, which move down by making tunnels inside. As a result, the shoots droop downward or dry up. Second, the larvae enter the fruits by making holes, rendering them unfit for human consumption. According to an estimate the spotted bollworm can cause 36-90% loss in the fruit yield of okra (Misra *et al*., 2002). Like other insects, the population of spotted bollworms is governed by their inherent capacity to increase, under the influence of various environmental factors.

Reproduction and survival in insects are influenced by a number of environmental factors including temperature, day length, humidity and precipitation, etc. (Reiter, 1989). Being cold blooded organisms, the body temperature of insects remains approximately the same as that of the surrounding environment. Therefore, it is believed that the effect of temperature on insects largely overwhelms the impact of environmental factors (Bale *et al*., 2002). Temperature may also have great influence upon the total number of eggs produced as well as the ovipositional behavior of insects

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0030-9923/2011/0005-0863 $ 8.00/0

(Cammel and Knight, 1992). Similarly, more frequent precipitation may exert a negative impact on the insect population because eggs and neonates of some insects may be dislodged or killed by rains (Kadam and Khaire, 1995).

Temperature and precipitation may affect the insects directly through changes in their physiology and indirectly from changes in the quality of host plants, and are considered to be the most important cause of population fluctuations because of their dominating effect on the survival, development and reproductive capacity of the pest.

Insects are capable of surviving only within certain environmental limits, so one can predict the occurrence of peak activities of a given pest through better understanding of preferred environmental factors. The present study was therefore undertaken to determine the role of different weather factors in infestation fluctuations of the spotted bollworms on okra.

MATERIALS AND METHODS

Two year studies were conducted to determine the role of weather in the fluctuation of fruit and shoot infestation caused by *Earias vittella* (Fab.) and *Earias insulana* (Boisd.) on three comparatively more susceptible (Parbani Karanti, Pusa sawani, Ikra-1), three moderately susceptible (PMS-beauty, Ikra anamika, Lakshami-24) and three comparatively least susceptible (Diksa, Sabz ari, Super Star) genotypes of okra under field conditions at Post Graduate Agriculture Research Station, University of Agriculture Faisalabad, during 2006 and 2007. Experiments were laid out in a Randomized Complete Block Design (RCBD) with nine treatments and three replications. The plot size was kept at 8.5 × 8.5 m, with 0.60 m row-to-row and 0.30 m plant-to-plant distance. All the recommended agronomic practices were carried out on experimental plot except control measures against spotted bollworms. Data on fruit infestation were taken by counting damaged and undamaged fruits from randomly selected five plants from each plot. Percentage fruit infestation was calculated by dividing the damaged fruits by total number of fruits and multiplying it with one hundred. Data on shoot infestation were taken by counting infested and uninfested shoots, from randomly selected twenty-five plants from each plot. Percentage shoot infestation was calculated by dividing the infested shoot by total number of shoot and multiplying it with one hundred. Observations were taken at weekly interval during both the years, starting from sixth week after germination. Meteorological data relevant to temperature, relative humidity and rainfall were recorded, from the adjoining meteorological observatory of the Ayub Agricultural Research Institute, Faisalabad. The data were subjected to square root transformation and simple correlation and multiple linear regression analyses were carried out using MSTATC package for both the years individually, as well as on average basis, to determine the impact of abiotic factors on the fruit and shoot infestation of *Earias vittella* (Fab.) and *Earias insulana* (Boisd.) on different genotypes of okra (Steel *et al*., 1990).

RESULTS

Fruit and shoot infestation

The data regarding fruit and shoot infestation versus weather factors during 2006 and 2007 are shown in Figures 1 and 2 with an objective to determine the trend in fluctuations of fruit and shoot infestation with respect to the weather conditions during the study period. The maximum fruit and shoot infestation was recorded on 12.6.2006 with a maximum temperature of 41.44^{o}C, minimum temperature of 24.40^{o}C, average temperature of 32.92^{o}C and relative humidity of 30.35%. During 2007, 2nd week of June (13.6.2007) was found to be the most favorable and resulted in a maximum fruit and shoot infestation, *i.e.,* 20.77 and 31.78%, respectively, with a maximum temperature of 44.61^{o}C, minimum temperature of 28.15^{o}C, average temperature of 36.38^{o}C and a relative humidity of 41.95%. On average basis of both years the 2nd week of June was found to be the most favorable and resulted in a maximum fruit and shoot infestation, *i.e.,* 18.64 and 30.11%, respectively, with maximum a temperature of 43.03^{o}C, minimum temperature of 26.28^{o}C, average temperature of 34.65^{o}C and a relative humidity of 36.15%.

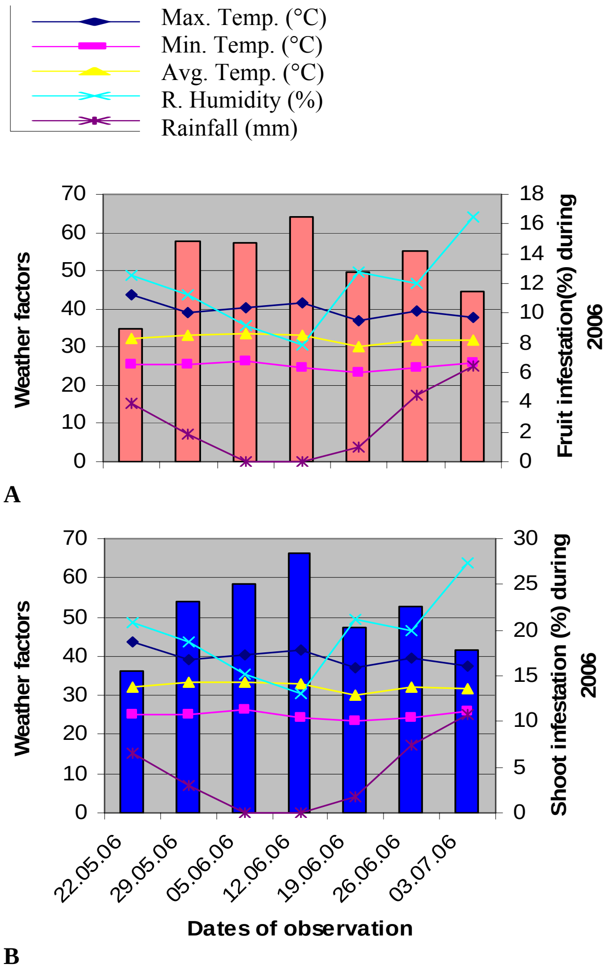

Fig. 1. Fruit (A) and shoot (B) infestation (%) caused by *Earias* spp. and weather factors on various dates of observation in different genotypes of 'okra' during 2006.

Correlation of weather factors with fruit infestation

Table I shows that all the weather factors had significant correlation with the fruit infestation, during both the study years as well as on average basis except in the case of minimum temperature during 2006. Maximum, minimum and average temperatures showed a positive response, whereas the relative humidity and rainfall exerted a negative response.

Table II shows that the maximum temperature was the most important factor and contributed 42% in the fluctuation of fruit infestation during 2006 and 80.6% in 2007. The 2nd most important factor was observed to be rainfall that exerted 27.5% influence on the fluctuation of fruit infestation. During 2007, minimum temperature, average temperature, relative humidity and rainfall contributed towards per unit change in fluctuation of fruit infestation up to 4.6%, 7.6%, 0.4% and 1.1%, respectively.

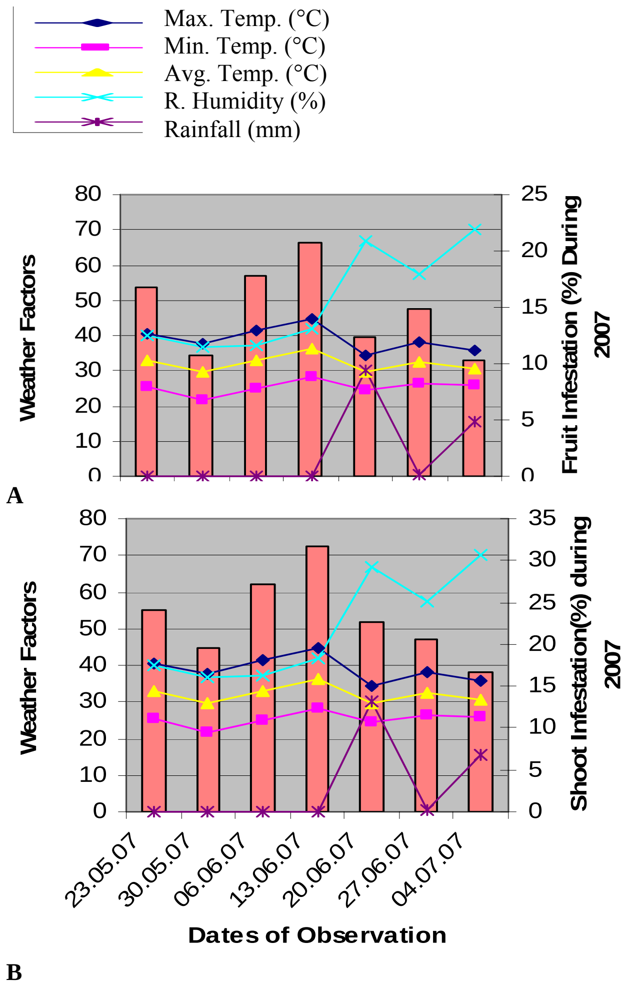

Fig. 2. Fruit (A) and shoot (B) infestation (%) caused by *Earias* spp. and weather factors on various dates of observation in different genotypes of 'okra' during 2007.

The impact of weather factors on an average basis for both years revealed that the maximum temperature again contributed maximum role, *i.e.*, 60.5% in the fruit infestation fluctuation. The minimum temperature, average temperature, relative humidity and rainfall showed a role of 0.8%, 0.2%,

Table I.- **Correlation between fruit and shoot infestation (%) caused by *Earias vittella* (Fab.) and *E. insulana* (Boisd.) and weather factors on 'okra' (*Abelmoschus esculentus* L.).**

Weather factors	Fruit infestation (%)			Shoot infestation (%)		
	2006	2007	Cumulative 2006-07	2006	2007	Cumulative 2006-07
Max. Temp. (ºC)	0.648 **	0.898 **	0.778 **	0.736 **	0. 815 **	0.730 **
Min. Temp. (ºC)	-0.099 ^{ns}	0.644 **	0.442 **	-0.075 ^{ns}	0.469 *	0. 289 ^{ns}
Avg. Temp. (ºC)	0.441 **	0.911 **	0.754 **	0.518 *	0.776 **	0.654 **
R. H. (%)	-0.687 **	-0.514 *	-0.513 **	0.819 **	-0.531 *	-0.606 **
Rainfall (mm)	-0.654 **	-0.561 **	-0.614 **	-0.759 **	-0.395 ^{ns}	-0.571 **

* = Significant at $P \leq 0.05$
** = Significant at $P \leq 0.01$
ns = Non- significant

0.0% and 5.5%, fluctuation in the fruit infestations by *Earias* spp. to the 'okra' crop (Table II).

Correlation of weather factors with shoot infestation

Table I shows that all weather factors showed significant effect on the shoot infestation except the minimum temperature during 2006 and the rainfall during 2007 which showed a non significant correlation with a negative response. On the cumulative basis for both years, the maximum temperature and average temperatures showed a positive significant effect, whereas the minimum temperature exerted a non significant correlation with the shoot infestation. Relative humidity and rainfall had a negative and significant correlation with the shoot infestation.

The impact of weather factors on the shoot infestation caused by *Earias* spp. on 'okra' during 2006 show that the maximum temperature exerted 54.2% role in the shoot infestation fluctuation which was the highest of any factor. The impact of this factor was positive and significant. Minimum temperature, average temperature, relative humidity and rainfall had 11.7, 6.1, 0.7 and 14.0% role, respectively, in the shoot infestation fluctuation.

The coefficient of determination values between shoot infestation and weather factors during 2007 revealed that the maximum temperature contributed the maximum role, i.e., 66.4%, towards the shoot infestation fluctuations. The minimum temperature, average temperature, relative humidity and rainfall had a 0.4, 14.0, 3.3 and 9.6% role in the shoot infestations fluctuation caused by *Earias* spp. in the 'okra' crop.

The Multiple Linear Regression Models along with the determination coefficient, regarding the impact of weather on the shoot infestation caused by *Earias* spp. on an average of both years, revealed that the maximum temperature was the most important weather factor, which contributed the maximum role, *i.e.*, 53.2% in the fluctuation of shoot infestation. The other factors, like minimum temperature, average temperature, relative humidity and rainfall, showed 0.3%, 0.6%, 0.9% and 0.5% role in the shoot infestation fluctuation, respectively.

DISCUSSION

Trends in insect infestation on okra may be affected by both biotic and abiotic factors, including crop phenology, natural biocontrol agents or environmental factors. Crop growth stages may present a varied availability of stems and fruits for insect attack. Similarly, natural enemies like predators, parasitoids and pathogens may also play a significant role in infestation fluctuation, as their efficiency effects with changing environmental conditions. Of all abiotic factors, temperature may have dominant role in the expression of insect infestation due to their cold blooded nature (Bale *et al.*, 2002). Within certain limits the increase in temperature besides affecting egg lying may increase the rate of feeding and metabolism and ultimately the speed of herbivory and developments (Pedigo, 2002; Danilevskii 1965). Furthermore increase in temperature also modifies crop physiological processes, response to injury due to

Table II.- Co-efficient of determination values (100 R^2) and actual role of weather factors in fluctuation of fruit infestation caused by *Earias vittella* (Fab.) and *E. insulana* (Boisd.) on 'okra' (*Abelmoschus esculentus* L.).

Weather factors	Fruit infestation (%)						Shoot infestation (%)					
	2006		2007		Cumulative 2006-07		2006		2007		Cumulative 2006-07	
	100 R^2	Actual role	100 R^2	Actual role	100 R^2	Actual role	100 R^2	Actual role	100 R^2	Actual role	100 R^2	Actual Role
Max. Temp. (°C)	42.0	42.0	80.6	80.6	60.5	60.5	54.2	54.2	66.4	66.4	53.2	53.2
Min. Temp. (°C)	53.2	11.1	85.2	4.6	61.3	0.8	65.9	11.7	66.8	0.4	53.5	0.3
Avg. Temp. (°C)	59.1	5.9	92.8	7.6	61.5	0.2	72.0	6.1	80.8	14.0	54.1	0.6
R. H. (%)	59.5	0.4	93.2	0.4	61.5	0	72.7	0.7	84.1	3.3	55.0	0.9
Rainfall (mm)	87.0	27.5	94.3	1.1	67.0	5.5	86.7	14.0	93.7	9.6	55.5	0.5

pest feeding and expression of resistance (Maxwell and Jennings, 1980). Sabri and Shahzad (2002) reported increase in rate of development of all stages of spotted bollworm with increase in temperature. In the present studies the positive significant correlation of maximum temperature with the fruit and shoot infestation may be attributed to this phenomenon. Comparable findings were reported by Shukla *et al*. (1997) who reported significant and positive correlation of mean maximum temperature with percent fruit damage with r values of 0.634 and 0.638, in the years, 1993 and 1994, respectively. According to Zala *et al.* (1999) maximum temperature exhibited significant positive influence on the incidence of larval activity on okra. Conversely, Ahmad *et al*. (2000) reported a significant and positive correlation with the minimum temperature and a negative correlation with the maximum temperature, whereas in the present study both the temperatures showed positive correlation with the pest incidence.

In okra crop the rains may dislodge the eggs and neonate larvae. Further more the secretions from the holes from biting points of okra fruits mix with water and the young larvae are get entangled due to their stickiness (Kadam and Khaire, 1995). Relative humidity and rainfall had significant negative and modest (below 0.69) correlation with fruit and shoot infestation in present studies, which may be attributed to the above mentioned hypothesis. Kumar and Urs (1988) and Patel and Patel (2000) also reported a negative effect of rainfall and relative humidity on the incidence of *E. vittella*.

The present findings are not in conformity with those of Gupta *et al*. (1998) who reported that increase in relative humidity by one unit would result in an increase of 0.595% shoot infestation. Furthermore, in the same study, it was reported that for every one unit increase in precipitation, there was 0.154% decrease in the fruit infestation and these results can, partially, be compared with the present findings, where one unit increase in rainfall resulted in 0.5% and 5.5% decrease in the shoot and fruit infestation, respectively.

In the field conditions, there exists a complex interaction between plant growth stage, biocontrol agents in the field, insect infestation and environmental temperature. The present study is not meant to present all these, but it just suggests that maximum temperature in the field is the most prominent factor for infestation of spotted bollworms on okra. There is a need of more elaborative studies to explore the influence of all these aspects on pest infestation on fruit and shoots of okra.

CONCLUSIONS

Maximum temperature in the field can be considered as dominant factor for the increase in fruit and shoot infestation of *Earias* spp. on okra, whereas rainfall and relative humidity exert only slightly negative effect.

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(Received 17 June 2010, revised 20 January 2011)