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Modelling population dynamics of army worm (*Spodoptera litura* F.) (Lepidoptera: Noctuiidae) in relation to meteorological factors in Multan, Punjab, Pakistan

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Abstract

Weather plays a critical void in mediating abundance of armyworms. Forecasting under such instances becomes fundamental for monitoring and management of this notorious pest particularly in developing countries where management cost is very high. Population data was taken from different locations of district Multan from 2006-2010 by Pests Warning Wing of Agriculture Department, Government of Punjab, Pakistan. Comparison of means of percent hot spots of armyworm revealed that armyworm population was at par during 2006-2010. Weather relation with *Spodoptera litura* F. abundance was summarized on the basis of Multivariate regression and correlation tactics. Multivariate regression analysis model unveiled coefficient of determination with armyworm abundance. Maximum temperature had significant negative impact on armyworm abundance while relative humidity had positive effect on armyworm population. Correlation analysis revealed that maximum temperature had negative correlation with armyworm abundance while relative humidity and rainfall had significant positive correlation on armyworm population during 2006-2010. Armyworm population build up initiated in the month of July and continued a constant threat till the end of cotton season. Hence management practices should be focused from the month of July and continued till the end of October.

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Introduction

Cotton is principally back bone of Pakistan's economy having share 2/3 of country's export. However, this major cash crop is affected by scores of insect pests which trigger substantial decline in cotton yield if not kept at the low ebb. Among these insect pests *Spodoptera litura* F. (Lepidoptera: Noctuiidae) has a key role as devastating pest of cotton crop feeding on *B*t and non Bt cotton genotypes. *Spodoptera litura* F. is polyphagous, multivoltine, highly fecundate, agile, notorious pest of cotton crop feeding on 112 crops in the world (Khetagoudar and Kandagal, 2012; Selvaraj et al., 2010). Meteorological factors play a very imperative role in regulation of armyworm population under agro-ecosystems (Selveraj et al., 2010). Positive/negative correlation of weather factors with armyworm abundance exists (Ali et al., 2008; Kong Ming and Yuyuan, 1995 and Jagginavar et al., 2007). Eruption and resurgence of the insect pests is linked with weather factors i.e., elevation or decline in temperature, abundance or scarcity of rainfall and remittance of susceptible varieties in ecosystems (Solbreck and Oikos, 1991).

Weather affects physiological and behavioral characters of insects leading to temporal and spatial dynamics (Kingsolver, 1989). Changing the focus of inquiry from mechanisms of population regulation to the interplay of biotic and abiotic factors re-establishes the conceptual importance of weather for population dynamics. Climatic change clearly revs up need for developing and implementing sound pest management strategies. Population ecologists accentuate need for demographic consequences of environmental or biological changes on herbivore pest species and need for precise and exhaustive forecast models in line with environmental factors (Varley and Gradwelt, 1970).

Meticulous pest forecasting is required to make the farmers aware of onslaught of insect pests in advance and thus, proper remedial measure can be made and applied to control pest population. Forecasting techniques rely on a biotic factors fluctuation, simplicity, accuracy of forecasting models and complete knowledge of biology, ecology, quantitative knowledge of insects attack, field studies, life history studies and detailed knowledge of insects (Hill, D., 1987). Temperature alone is a single most important factor controlling insects development and hence, population numbers or population out break (Wallner, 1987 and Weisser, et al., 1997). Rainfall on the other hand can be only reason for insect epidemic. Similarly, R.H above or below certain limits can augment or lessen development of pests under certain conditions (Beirne, 1970). Theoretical and applied entomologists focus on role of weather factors and their use in development of forecasting models (Wallner, 1987).

Review of literature has revealed that little and incomplete work has been conducted earlier on it. Present studies were planned to find out the time of resurgence, augmentation and peak attack of armyworm by correlating weather factors and armyworm abundance and help farmers make best integrated strategies like cultural control, mechanical control, biological control and chemical control for the upcoming year to save 25-100% economic loss touched off armyworm in cotton (Dhir et al., 1992; Prayogo et al., 2005) and soar cotton yield in Pakistan.

Materials and methods

Pest population data was taken from different locations of District Multan viz., Tehsil Shujabad, Tehsil Jalalpur Pirwala and Tehsil Multan ranging from 36° to 60° north and 59° to 86° east covering 0.4 million acres areas. Pest scouting was conducted in 40 spots (5 acre each, taken randomly from each Tehsil on weekly basis from 1st June to 31st October) each year from 2006-2010. The data from 40 spots collected from each tehsil was converted into replicates. Meteorological data was also taken from Weather record station at Central Cotton Research Institute, Multan.

Armyworm population was recorded as occurrence or non-occurrence in the field. A spot was considered hot spot where population of pest was found at ETL and above ETL. From forty spots examined, a spot was considered hot spot where population of each pest was found at ETL and above ETL on weekly basis and percent hot spot of each pest from each location (Multan, Shujabad and Jalalpur Pirwala) was determined. Data was analyzed using MSTAT-C (Annonymous, 1986) software. Regression and correlation was made between weather factors and insect pests using Minitab software (MCKenzie and Goldman, 1999). Values were considered significant if $p \leq 0.05$ and Highly Significant if $P \leq 0.01$.

Results

Pest scouting during 2006 to 2010 revealed that in 2006, pest population increased gradually from 1st June and reached at its peak in 4th week of July, due to rain fall 14mm which favored pest development and high humidity, pest population declined in 1st week of August due to absence of rainfall, pest management practices and pest pupation, again surged in 2nd week of August again declined then surged and increased rapidly till 4th week of September high humidity 64-73% and rain fall which disabled farmers to apply pest management practices again declined and surged in 3rd week of October. In 2007 pest population developed from 4th week of July and increased steadily and reached at its peak in 2nd week of September, then declined due to pest management practice and again reached at its peak in 2nd week of October again declined by crop maturity.

Table 1. Population fluctuation of armyworm during 2006-2010.

Year	*AW*
2006	14.209 d
2007	12.371 e
2008	17.44c
2009	18.48 b
2010	20.27 a
LSD	0.3666

Table 2. Correlation of Metrological factors with Armyworm (*Spodoptera litura* F).

Year	*Max. Temp*	*Min. Temp*	*RF*	*RH*
2006	-0.463*	-0.507*	0.090	0.392
2007	-0.099	0.221	0.093	0.140
2008	-0.133	0.033	0.821**	0.655**
2009	-0.248	-0.289	-0.063	0.065
2010	-0.237	-0.396	-0.128	0.055

Significant * =P<0.05 Highly Significant ** P<0.0.1.

In 2008, pest population increased gradually from 4th week of July and this increase was much higher and steadily increase was seen till 3rd week of August, due to continuum of rainfall, high humidity which favored pest development, declined in last week of August and surged in 2nd week of September and declined again surged in 4th week of September to 2nd week of October and then declined (Fig 1; Table 3). In 2009 pest population out break was observed since last week of July and then increased steadily in August due to presence of rainfall and high humidity which favored pest development, declined in 1st week of September again surged in 2nd week of September due to rainfall and pest pressure, again declined in 1st week of October and surged in 2nd week of October, then declined due to crop maturity (Fig 1; Table 3).

In 2010 pest population increased gradually from 4th week of July and reached at peak in 1st week of

August, declined then till 3rd week of August and surged in 1st week of September and reached at its peak in 2nd week of September then declined by pest management practices (Fig 1; Table 3). Population fluctuation of army worm from 2006 to 2010 derived from comparison of means revealed that armyworm population was at its peak in 2010 followed by 2009, 2008, 2007 and 2006 (Table 1).

Table 3. Multivariate regression models along with coefficient of determination between weather factors and Armyworm population during 2006-2010.

Insect	*Regression equation*	*R2*	*100 R2*	*Role of individual factor*
2006	Y = 118 - 2.86** X1	0.662	66.2	48.1 x 1
	Y = 123 - 2.00**X1 - 1.37 X2	0.722	72.2	6.0 x 2
	Y = 122 - 1.89** X1 - 1.48 X2 - 1.93 X3	0.762	76.2	4.0 x 3
	Y = 69.2 - 1.01**X1 - 1.84*X2 - 1.78 X3 + 0.450 X4	0.323	82.3	6.1 x 4
2007	Y = 104 - 2.46 X1	0.252	25.2	25.2 x 1
	Y = 99.9 - 2.20 X1 - 0.194 X2	0.257	25.7	0.50 x 2
	Y = 101 - 2.21 X1 - 0.191 X2 - 2.16 X3	0.336	33.6	7.90 x 3
	Y = 52.4 - 1.25 X1 - 0.402 X2 - 2.31 X3 + 0.272 X4	0.363	36.3	2.7 x 4
2008	Y = - 1.7 + 0.64 X1	0.054	5.4	5.4 x1
	Y = - 32.5 + 2.92 X1 - 2.02 X2	0.081	10.9	5.5 x 2
	Y = - 31.5 + 2.72 X1 - 1.72 X2 - 10.5 X3	0.170	17.9	7.0 x 3
	Y = - 111 + 2.68 X1 - 1.22 X2 - 8.22 X3 + 0.882 X4	0.197	26.9	9.9 x 4
2009	Y = 163 - 3.80**X1	0.517	51.7	51.7 x 1
	Y = 156 - 3.33**X1 - 0.440 X2	0.528	52.8	1.1 x 2
	Y= 154 - 3.23**X1 - 0.531 X2 + 10.5 X3	0.601	60.1	7.3 x 3
	Y = 102 - 2.33**X1 - 0.670 X2 + 8.63 X3 + 0.316 X4	0.642	64.2	4.1 x 4
2010	Y = 84.0 - 1.73** X1	0.158	15.8	15.8 x 1
	Y = 72.3 - 3.11 X2 + 2.44 X3	0.255	25.5	9.70 x 2
	Y= - 37.1 - 0.15 X1 + 0.25 X2 + 0.857 X3	0.623	62.3	36.8 x 3
	Y = - 35.5 - 0.07X1 + 0.18 X2 + 0.792 X3 + 0.540** X4	0.631	63.1	0.8 x 4

X1= Max. Temperature X2= Min. Temperature X3=R.H X4= Rainfall
Significant * =P<0.05 Highly Significant ** P<0.0.

Multivariate regression analysis table during 2006 to 2010 revealed that population showed negative linear relation with maximum temperature (5.4 to 51.7%) in all consecutive years while the population showed negative highly significant relationship with increase in minimum temperature (1.1 to 9.7%)(Table 3). Relative humidity showed positive linear relation with increase in population of armyworm from 2006 to 2010 and the role of individual factors was 2.7 to 9.9% (Table3). The population showed highly significant negative linear relation with rainfall (0.50-7.3%).

Correlation matrix (Table 2) showed that armyworm showed highly significant negative correlation with maximum temperature (-0.719 to 3.33%), high minimum temperature (-0.749 to 0.161%) and rainfall (-0.145 to -0.244%) while highly positive correlation (0.200 to 0.789%) was observed with increase in relative humidity with peak values in 2006 and 2010.

Discussion

Spodoptera litura and *Spodoptera littoralis* has attained status of regular pest since introduction of Bt Cotton varieties. *Spodoptera* is a large group consisting of many species however on cotton only *litura, exigua* and *littoralis* are reported. Population abundance in 2006 to 2010 depicts that army worm population was at its peak in 2007-2008 and in 2010 (Table 1). We observed 3 generations of armyworm in our work in each cotton season on cotton crop. Ghaffar et al., 2006 reported two generations of *Spodoptera* from September to November and one generation at seedling stage. Results of present studies were similar to Ghaffar et al., 2006. South Punjab in Pakistan in 2010 faced heavy floods. Our results demonstrate highest population of armyworms in 2010 which may be due to heavy rainfall and high humidity in cotton zone. We observed significant and positive correlation with relative humidity while negative correlation was observed by maximum temperature, minimum temperature and rain fall. Results of present studies were analogous to Holt et al., (1999) who elaborated that moths of armyworm concentrated by convergent wind flows associated with rainstorms. The moths land and breed resulting in outbreak of larvae at high densities which cause considerable damage to crops. We in the present studies also observed maximum population of armyworm in the month of August which was accompanied with rain fall and high relative humidity and wind storms. We in the present studies observed three generations of armyworms on cotton crop during August to October. In the month of June in Pakistan there is high temperature coupled with low atmospheric pressure. This results in low reproduction rate of insect on cotton crop. Hence pests observation is rare under such circumstances. Present results were similar to Pellegrino et al., (2013) who studied role of atmospheric pressure in sexual behavior in armyworms. According Pellegrino et al (2013) armyworms male in response to decreasing barometric pressure exhibit decreased locomotory activity in Y tube olfactometer and with female pheromone extracts. However, when they were placed in proximity to females very low mating behavior was observed. Results of present studies were in contradiction with Selveraj et al., 2010 who elaborated that maximum population of armyworm was observed 93 DAS (days after sowing). Our studies clearly documents peak population of armyworm in the month of August in South Punjab *i,e* 75 DAS (days after sowing). Moreover results of present studies document peak population of armyworm during August to mid-October with 3 generations on cotton crop during 2006-2010. Results of present studies were similar to Parsad et al., 2013 who observed population of *Spodoptera litura* from July-August. Present studies also document significantly positive correlation of relative humidity and rainfall on armyworm concentration. However, negative effects of maximum temperature and low crop stage on pest abundance was observed. Persad et al., 2013 observed outbreaks of *Spodoptera litura* in seasons experiencing monsoon coupled with more than normal rainy days and rainfall of >20 mm during June to August. Our results were analogous to Persad et al., 2013. We on the basis of our result recommend farmers give particular attention to pest control during August to mid October because armyworm lay eggs in clusters and hence slight negligence by farmers may lead to high losses to farmers because when the pest is well developed on crop then it becomes difficult to control it.

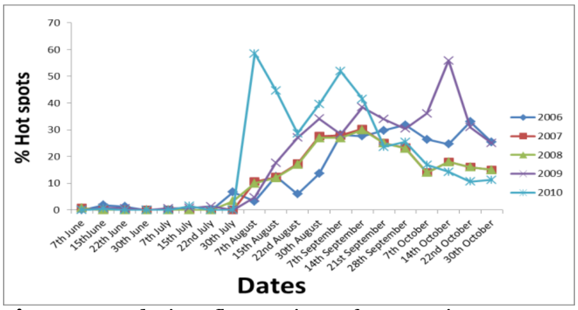

Fig. 1. Population fluctuation of cotton insect pests with weather factors during 2006-2010.

Conclusion

Results of present studies conclusively document that relative humidity and rainfall depicted significant positive correlation with armyworm abundance while maximum temperature had negative correlation with armyworm population. Three generation of Armyworm were observed on cotton crop from June to mid-October. Maximum population peak was observed in the month of August. Month of August in Pakistan is accompanied with monsoon rains which increased relative humidity of environment and hence population of armyworms increases intensively. Farmers in Pakistan should start pest scouting in cotton field once in a week from the month of May and apply integrated management against it from June to mid- October to keep its population at the low ebb otherwise, economic damage will occur.

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