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Path analysis of climatic factors affects the population of spotted bollworm, *Earias insulana* (Boisduval) lepidoptera-noctuidae in cotton

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Abstract
The Path analysis of climatic factors affects the population of Spotted Bollworm (SBW), *Earias insulana* (Boisduval) Lepidoptera–Noctuidae in Cotton was assessed at the Jawharlal Nehru Agriculture University, Cotton Research Station, Khandwa M.P. The perusal of data on the population of Spotted Bollworm (SBW) revealed that the spotted bollworm, *Earias insulana* was first observed during the 28th SMW i.e. I week of July and remained active till 47th SMW (4th week of November). The peak population level was observed during 35th SMW i.e. Ist week of September. The correlation studies between SBW population and weather factors revealed that the SBW population had a significant positive correlation with min temperature, morning relative humidity, evening relative humidity, wind velocity. The multiple regression computed involving combined effect of maximum temperature (X1), minimum temperature (X2), morning relative humidity (X3), evening relative humidity (X4), sunshine hours (X5), wind velocity (X6), rainfall (X7) and rainy day (X8) was Y=-69.557+0.798X1+0.745X2 +0.332X3+0.113X4+0.296X5+0.043X6+0.043X7-0.914X8 R^2=0.724). The Path coefficient analysis revealed that minimum temperature had positive and high direct effect on larval population of spotted bollworm, followed by morning relative humidity and evening relative humidity, respectively. Overall result of the experiment it can be concluded that mild rainfall with mild to high temperature (26 to 34 ºC) and high humidity (>60 %) were congenial for the multiplication of the pest.

Keywords: Cotton, spotted bollworm (SBW), *Earias insulana*, weather, population

Introduction
Cotton was referred to in a Hindu Rig-Veda hymn mentioning "threads in the loom" [1]. It cultivation in the old world began from India, where cotton has been grown for more than 6,000 years, since the pre-harappan period. India is one of the major producers of cotton in the world with the largest acreage, which is almost one fourth of world area. The production share is however, only 13.5 percent ranking third in the world. The production and productivity of cotton is highly influenced by biotic and abiotic factors. Among various key factors responsible for poor yield of cotton in India, the damage caused by large number of insect pests during different stages of crop growth are of prime importance. Several insect pests ravage it, which causes drastic reduction in the yield. Rainwater [2] remarked that cotton plant is specially tailored for insect. About 1326 insects and mites from all over the world [3]. In India, Cotton is damaged by 162 insect species. Of these, 24 have attained the pest status, out of which 9 are "key" pests in different zones [4]. Among these, Spotted Bollworm (SBW), *Earias insulana* (Boisduval), family: Noctuidae, order: Lepidoptera, is one of the insect pests of national importance that damaging the crop in all the cotton growing zones of the country. It attacks the crop from 35 to 110 days of the age. Moths lay eggs on flower buds, branches and twigs, pupation takes place inside cocoon in fallen buds, plant debris or soil. Caterpillars cause damage by boring into the growing shoots, buds, flowers and bolls. The infested shoots droop and ultimately die, and flowers and buds drop off. It caused considerable direct yield losses by feeding and indirect damage by reducing quality and marketability of infested crops [5]. Although the main control against this insect is aerial spraying of pesticides but the continuous use of pesticides has resulted in resurgence of pesticide-resistant insect populations and elevation of secondary pests to a status of primary importance [6]. Therefore, there is need to evolve an effective and safe management modules. Keeping in view, a field trial was conducted for study the effect of climatic factors on the population build up of SBW.

Materials and Methods

The population dynamics of Spotted Bollworm (SBW),*Earias insulana* (Boisduval) Lepidoptera Noctuidae in relation to environmental factors was assessed at the Jawaharlal Nehru Agriculture University, Cotton Research Station, Khandwa M.P. The Cotton, *Hirsutum* variety JK-4 was sown in observation plot of 4000 sq. m under rain fed condition in black cotton soil during the last week of June in both the year of studied. All the normal agronomical practices recommended for the region were followed for raising the crop. No plant protection measure was taken throughout the crop season. The regular observations on the population dynamics of SBW larvae was made at weekly interval by randomly selected 25 plants from first appearance of pest until its termination.

At the same time, observations on meteorological parameters *viz.* minimum and maximum temperature, morning and evening percent relative humidity, total rainfall per week, total rainy days per week, wind velocity (kmph) and sunshine hours per days were recorded daily. Standard meteorological Week (SMW) average of all the data collected for the pest, weather factors were calculated before statistical analysis. The data thus, collected were computed and subjected to statistical analysis [6]. All the possible correlations, multiple regression and path analysis among the environmental factors were worked out [7].

Results and Discussion

Population Dynamics of SBW

The data of spotted bollworm (SBW) population was showed in Figure: 1 revealed that the SBW was first observed during the 28th SMW i.e. I week of July and remained active till 47th SMW (4th week of November). The peak population level was observed (16.33 larvae / 5 plants) during 35th SMW i.e. Ist week of Sep. The weather condition prevailed during this week viz. maximum temperature, minimum temperature, morning relative humidity, evening relative humidity, sunshine hours, wind velocity, rainfall and rainy day were 34.11°C, 25.49°C, 76.54 %, 39.56%, 8.29 hours per day, 6.94 kmph, 18.50 mm and 0.50 days respectively. These finding agreement with Butani [8], whose observed that the period of maximum damage caused by spotted bollworm is being in the month of September. Taneja and Jayaswal [9] also observed similar result, those noticed the activity of spotted bollworm on cotton from mid July to end of September with maximum during first fore night of September.

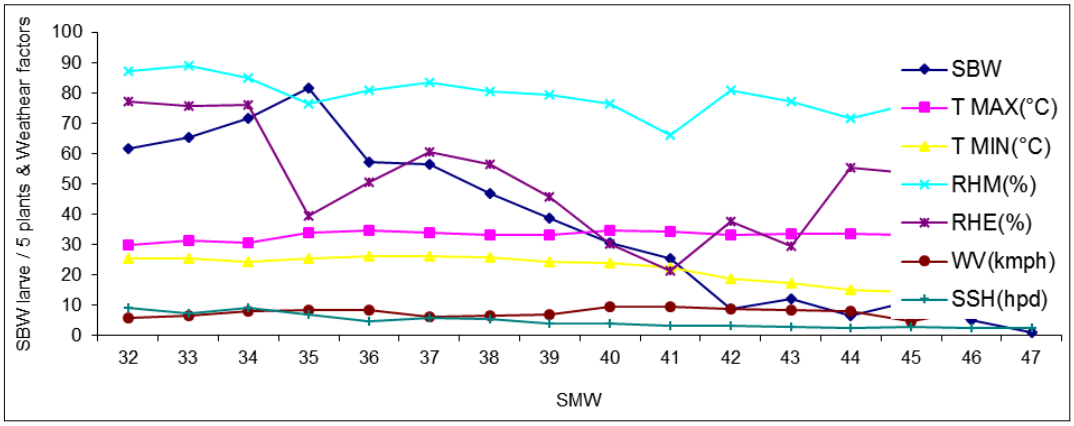

Fig 1: Effect of weathear factors on the population of spotted bollworm.

Simple Correlation and Regression

The data in table: 1 showed that the simple correlation studies between Spotted bollworm population and climatic factors revealed that the SBW population had a significant positive correlation with Minimum temperature (r=736), Morning relative humidity (r=0.556), Evening relative humidity (r=0.513), wind velocity (r=0.512). It was estimated that every unit increase in Minimum temperature, Morning relative humidity, Evening relative humidity, and Wind velocity, there is increase in population of SBW is 0.833, 0.555, 0.173 and 0.86 respectively. Similar result was observed by Ahmad *et al.* [10] who revealed that significant positive correlation with the minimum temperature and morning and evening relative humidity respectively. Moreever, Zala *et al.* [11] were reported that minimum temperature showed a significant positive effect, similar to present finding and on contrary, relative humidity had a significant negative influence on larval of Earias vittella. Furthermore, Mohapatra *et al.* [12] also reported positive relationship between population build up of *Earias vittella* with minimum temperature those similar to present findings and significant negative correlation with morning relative humidity that is dissimilar to present finding.

Table 1: Correlation (r) and simple regression (Y) of spotted bollworms, *Earias spp.* population with abiotic factors

S. No.	Character	First Year	Second Year	Pooled of two year
1	T Max	r= -0.371	r= -0.148	r= -0.244
2	T Min	0.580** Y=-10.701+0.765X	0.744** Y=4.932+1.404X	0.736** Y=-11.248+0.833X
3	RHM	r= 0.580** Y=-38.411+0.577X	r= 0.501* Y=-33.932+0.519X	r= 0.556* Y=-36.957+0.555X
4	RHE	r= 0.450** Y=-1.097+0.156X	r= 0.503* Y=-1.294+0.176X	r= 0.513* Y=-1.666+0.173X
5	SSH	r= 0.090	r= -0.520* Y=18.262-1.451X	r= -0.284
6	WV	r= 0.528* Y=1.734+0.821X	r= 0.434* Y=3.452+0.789X	r= 0.512* Y=2.169+0.86X
7	RF	r= 0.363	r= 0.438* Y=6.179+0.059X	r= 0.283
8	RD	r= 0.296	r= 0.563** Y=1.01+0.038X	r= 0.231

*& ** Showed significant at 5% & 1% level of significance respectively

Multiple Regression Analysis

The multiple regression computed (figure 2) with eight parameters i.e. maximum temperature (X1), minimum temperature (X2), morning relative humidity (X3), evening relative humidity (X4), sunshine hours (X5), wind velocity (X6), rainfall (X7), and rainy day (X8), as independent variables and Spotted bollworm population as dependent variables was as follows

$Y=-69.557 + 0.798X1 + 0.745X2 + 0.332X3 + 0.113X4 + 0.296X5 + 0.043X6 + 0.043X7-0.914X8 \quad (R^2=0.724)$

The multiple coefficient value between the spotted bollworm population and group of variable clearly indicated that 72.40 % change in SBW population were affected by maximum temperature, minimum temperature, morning relative humidity, evening relative humidity, sunshine hours, wind velocity, rainfall and rainy day.

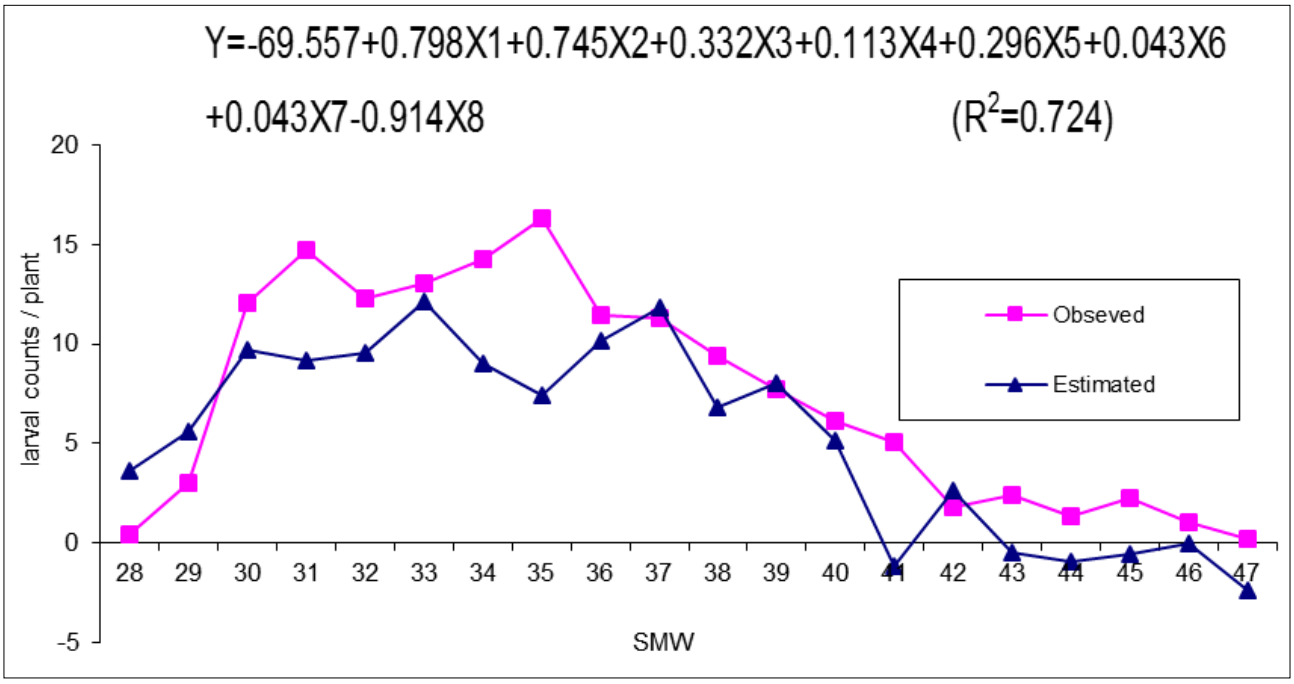

Fig 2: Mulltiple regession of weather factors on Spotted bollworm population

Path analysis

Path coefficient analyses of various abiotic factors with SBW have been presented in table: 2 and figure: 3. The weather factor exhibited significant positive correlations with SBW population were minimum temperature (0.5497), morning relative humidity (0.4162), evening relative humidity (0.4175), rainfall (0.5546) and rainy days (0.4992) respectively. The data presented in table: 2 and figure:3 revealed that minimum temperature had positive and high direct effect (1.4228), followed by morning relative humidity (0.4939) and evening relative humidity (0.0026), respectively. Path coefficient effect revealed that the positive indirect effect of high magnitude of minimum temperature was obtained via evening relative humidity (0.0009). The positive indirect effect of morning relative humidity was obtained via wind velocity (0.0482), evening relative humidity (0.0012) and wind velocity (0.0482).The positive indirect effect of evening relative humidity was obtained via minimum temperature (0.5127), morning relative humidity (0.2335) and sun shine hours (0.0218).

Table 2: Path coefficient of abiotic factor on SBW, *Earias spp* larvae population on cotton

	T MX (°C)	T MN (°C	RHM (%)	RHE (%)	SSH (hpd)	WV (kmph)	RF (mm)	RD (dpw)	Correlation Coefficient
T MX	0.5566	0.8953	-0.0008	0.0001	-0.1373	-0.1960	0.0102	0.0177	0.0326
T MN	-0.3503	1.4228	-0.0062	0.0009	-0.0593	-0.3341	-0.0828	-0.4140	0.5497**
RHM	0.0009	-0.0178	0.4939	0.0012	-0.0204	0.0482	-0.0452	-0.0447	0.4162*
RHE	-0.0229	0.5127	0.2335	0.0026	0.0218	-0.2109	-0.0696	-0.0497	0.4175*
SSH	-0.4366	0.4819	0.0575	-0.0003	-0.1750	-0.0839	0.0558	0.0388	0.0619
WV	-0.2549	1.1106	-0.0556	0.0013	-0.0343	-0.4280	-0.0744	-0.0215	0.2432
RF	0.0364	0.7587	0.1438	0.0012	0.0629	-0.2051	-0.1552	-0.0881	0.5546**
RD	0.0817	0.4876	0.1828	0.0011	0.0563	-0.0763	-0.1132	-0.1208	0.4992**

Residual=0.5186, *& ** Showed significant at 5% & 1% level of significance respectively, The bold figures denote the direct effect of different factors on population of pest

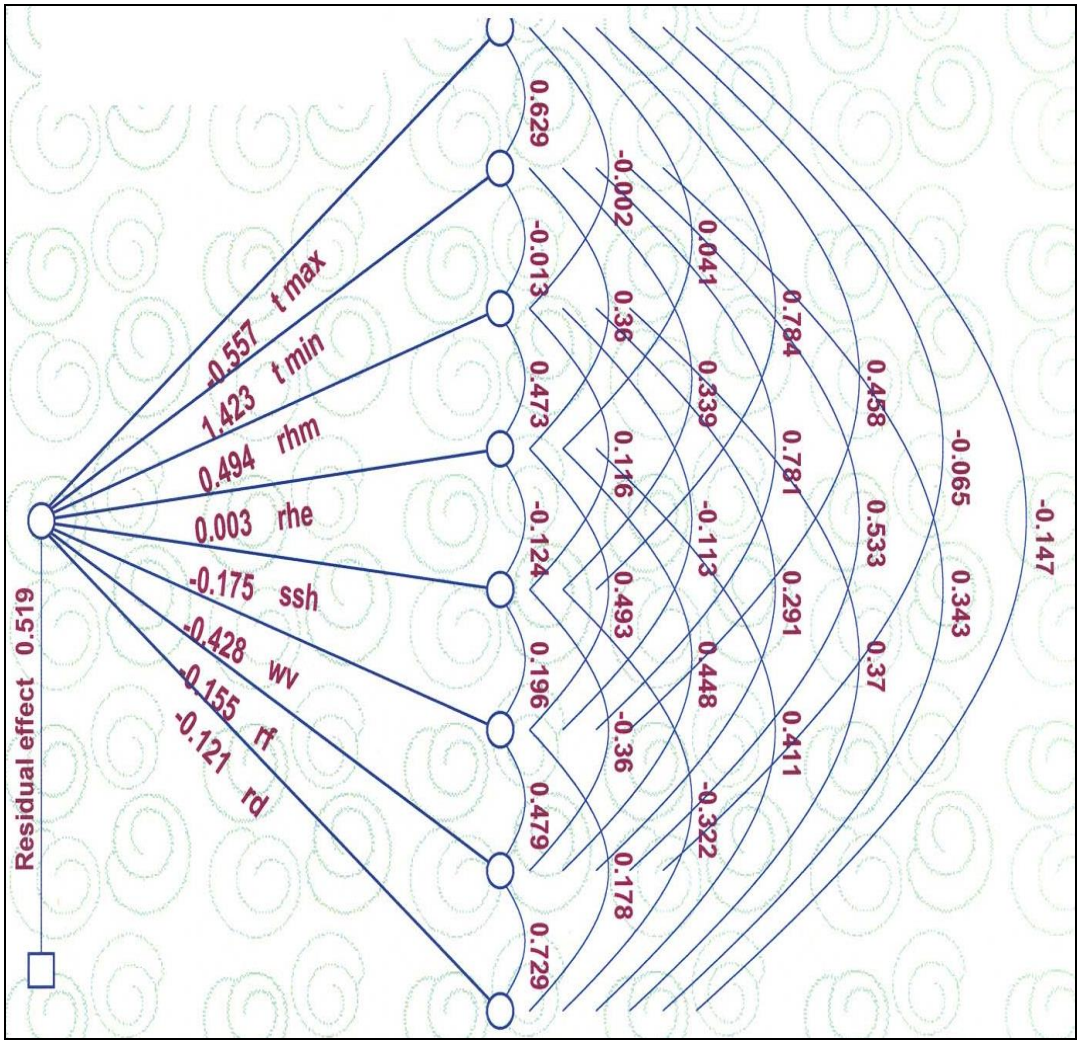

Fig 3: Path diagram showing influence of various factors on the population of spotted bollworms

Conclusion

In the present investigation, it can be concluded that climatic factors play the vital role for build up the population of SBW. The multiple linear regression analysis raveled that the major climatic factors together were responsible for a total variation of 72 % in SBW population. Mild rainfall with mild to high temperature (26 to 34 ºC) and high humidity (>60 %) were congenial for the multiplication of the pest.

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