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Research Article

DIRECT AND INDIRECT EFFECT OF ABIOTIC FACTORS ON POPULATION FLUCTUATION OF *H. armigera* IN CHICKPEA

KHORASIYA S.G., RAGHAVANI K.L. AND BHARADIYA A.M.*

Department of Entomology, Junagadh Agricultural University, Junagadh Road, Motibag, Junagadh, 362001, Gujarat
*Corresponding Author: Email-ambharadiya@jau.in

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Abstract- Direct and indirect effect of various abiotic factors on population build-up of *H. armigera* indicated that maximum temperature exerted very high negative direct effect (-1.1428) while morning relative humidity registered positive and high direct effect (0.4842). Negative high indirect effect was noticed of minimum temperature (-0.8909), morning (-0.4419) and evening relative humidity (-0.3891) through maximum temperature. While remaining weather parameters showed moderate to low positive indirect effect except evening relative humidity on population build-up of *H. armigera* during 2011-12. Minimum temperature (-0.5537), morning relative humidity (-0.9521) and wind speed (-0.4425) exerted negative high direct influence while, evening relative humidity (0.9534) exerted positive high direct influence on population build-up of *H. armigera*. Morning relative humidity exerted high negative indirect effect (-0.8193) through evening relative humidity and high positive indirect effect through wind speed (0.4493) and evaporation (0.6588) during *rabi,* 2012-13.

Keywords- Direct-indirect effect, Abiotic factors, Population fluctuation, Gram pod borer, *H. armigera*, Chickpea

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Academic Editor / Reviewer:

Introduction

Chickpea (*Cicer arielinun* l Linn.) also known as bengal gram or gram. chana, garbanzo etc., is one of the most important pulse crops of India and is considered as "King of Pulses" [2]. India accounts for 68 % of total global output of chickpea and incidentally it is one of the largest consumers. Chickpea is grown in about 8.68 million hectare in India with tentative production of 5.35 million tonnes. In 2010-11, the estimated production was about 8.25 MT, a record in the last 50 year. Four states *viz*, Madhya- Pradesh, Uttar- Pradesh, Maharashtra and Rajasthan together contribute about 87% of production from area. In Gujarat, area under chickpea has been reported 2.39 lakh hectares with total production of 2.73 lakh tones and productivity of 1139 kg/ha during rabi 2011-12 [3].

The productivity of chickpea crop has not witnessed any significant jump as compared to the cereal crops, because of several biotic and abiotic constraints. Among the many biotic factors responsible for low yield, damage due to insect pests is the major limiting factor [1]. Chickpea crop is attacked by nearly 57 species of insect and other arthropods in India [4]. Among them, pod borer *Helicoverpa armigera* (Hubner) (Lepidoptera: Noctuidae) is most important and accounts for about 90 to 95 % of the total damage caused by all the insect pests [7]. This pests is popularly known as "gram pod borer", while in the U.S.A., it is called "bollworm" or "American bollworm" or "Corn worm". Synonyms of gram pod borer *Heliothis armigera* (Hubner) reported by [8] are as *Heliothis obsoleta* Fabricius, *Helicoverpa armigera* (Hubner), *Chloridae armigera* (Hubner) and *Chloridae obsoleta* Fabricius. It has been reported 3.6 - 72.8 per cent pod damage in chickpea [6].

Chickpea is one of the major pulse crops in India and widely grown in Saurashtra region of Gujarat State. This crop is attacked by *H. armigera*, which causes the economic damage. Due to the development of resistance toward the commonly used insecticides, this pest has created a serious threat to the agricultural industry in the recent years. However, pest population is mainly governed by almost all the environmental factors. The information regarding effect of abiotic factors on population fluctuation and their correlation is quite useful to study the relationship of weather parameter on pest incidence. Hence, the present investigation was carried on determination of the direct-indirect effect of abiotic factors on the population fluctuation of gram pod borer, *H. armigera* in chickpea.

Materials and Methods

The association of insect pest population and different abiotic factors was ascertained by computing correlation coefficient, which gave strength and direction of association and provided the mutual association between the two character (weekly average insect pests population and any one of the abiotic factors). The correlation, however, did not reflect actual contribution of individual abiotic factor on insect pests population and, therefore, it becomes difficult to determine the influence of a particular abiotic factor on the expressivity of dependent variable (weekly average insect pests population per plant), where confounding effects was encountered. The path coefficient analysis on the other hand, describes direct and indirect effects of each of the variables and gives the path in which an independent variable is affecting the dependent variable in a given set of independent variables [5].

During the present investigation, the effect (direct as well as indirect) of ten different abiotic parameter *i.e.* maximum temperature (X_1), minimum temperature (X_2), relative humidity percentage at morning (X_3), relative humidity percentage at evening (X_4), sunshine hours (X_5), wind velocity (X_6), evaporation (X_7) on the population build-up of *H. armigera* insect pests was studied with the help of path coefficient analysis.

A path coefficient was obtained by solving simultaneous equation, which represents the basic relationship between correlation and path coefficient of the

form given below.

$$R_{iy} = P_{1y}.r_{i1} + P_{2y} . r_{i2} + \ldots\ldots\ldots + P_{i-1y} . r_{i,i-1} + \ldots\ldots\ldots + P_{iy} + P_{i+1y} . r_{i,i+1} + \ldots\ldots\ldots + P_{ky} . r_{ik} . \quad \text{for } i = 1, 2, \ldots\ldots\ldots k. \quad \text{[Eq-1]}$$

Where,

P_{1y}, P_{2y}..... P_{ky} are the coefficients in the linear relation and are known as path coefficients: r_{i1}, r_{i2}, ... r_{ik} are simple correlation coefficient among independent variables (abiotic factors) and r_{iy} is the simple correlation coefficient between i^{th} independent variable X_1 and dependent variable Y (average insect pests population per plant). Piy is the direct effect of X_i on Y and $P_{1y}. r_{i1}$..... $P_{i-1,y} . r_{i,}$ i-2' Pi + 1, y ri, i + 1..... Pky rik are indirect on X_i on Y through X_1, X_2, X_3 ... $X_{i-1'} X_{i+1'}$..... $X_{k'}$. Therefore, the simple correlation coefficient (Total effect) between X_i and Y is the sum of direct and indirect effects of X_i on Y.

The residual variation which is the variation due to uncontrolled causes in dependent characters (insect pests population) was estimated be the following relationship.

$$\text{Residual effect } (P_{RY}) = 1 - (P_{1y}.r1y + P_{2y}.r_{2y} + \ldots\ldots\ldots + P_{ky}.r_{ky}) \quad \text{[Eq-2]}$$

The weekly weather parameters was obtained from meteorological observatory of Central Experimental Research Station, Junagadh Agricultural University, Junagadh, in order to study the effect of weather parameters on the population of *H. armigera* on chickpea, correlation between the various weather parameters and pest incidence was worked out with the help of statistically analysis software.

Values of direct and indirect effect calculated during both seasons were classified in different range as listed below.

Sr. No.	Range of value	Effect
1	0 - 0.09	Negligible
2	0.10 - 0.19	Low
3	0.20 - 0.29	Moderate
4	0.30 - 0.99	High
5	>1.0	Very high

Results and Discussion

Effect of abiotic factors on *H. armigera* (*Rabi*, 2011-12)

The data presented in [Table-1] indicated the direct and indirect effect of various abiotic factors on population build-up of *H. armigera* during *rabi* season of 2011-12.

Effect of maximum temperature on population build-up of *H. armigera*

The maximum temperature exhibited highly significant negative correlation (r = -0.8184**) with *H. armigera* population and it also exerted negative very high direct effect (-1.1428) on *H. armigera* population. Indirect effect of evening relative humidity was found negative and low (-0.0719), whereas, the indirect effect of morning relative humidity and wind speed were positive moderate (0.1872 and 0.1527) on *H. armigera* population. These parameters showed positively low indirect effect through minimum temperature (0.0349), bright sunshine hours (0.0143) and evaporation (0.0071) on population build-up of *H. armigera*.

Effect of minimum temperature on population build-up of *H. armigera*

The mean temperature had a significant negative association (r = -0.6290*), its direct effect (0.0448) was positive and very low on *H. armigera* population. However, the indirect effect of morning relative humidity was found positively low morning relative humidity (0.1480), wind speed (0.1145) and bright sunshine hours (0.0864) on *H. armigera* population. It exhibited negative and high indirect influence (-0.8908) through maximum temperature while, negatively low indirect effect was exhibited through evening relative humidity (-0.1312) and evaporation (-0.0007) on population fluctuation of *H .armigera*.

Effect of morning relative humidity on population build-up of *H. armigera*

The morning relative humidity had a non-significant positive association (r = 0.1169) with *H. armigera* population and it also exhibited positive moderate (0.4842) direct effect on *H. armigera* population. The wind speed exhibited moderate (0.2167). While, evening relative humidity (0.0141), minimum temperature (0.0137) exhibited positive and low indirect effect on population build-up of *H. armigera*. However, negative moderate indirect effect (-0.4419) was exerted through maximum temperature and low indirect influence (-0.1537 and -0.0162) were exerted through evening relative humidity and evaporation, respectively on population fluctuation of *H. armigera*.

Effect of evening relative humidity on population build-up of *H. armigera*

The evening relative humidity having a non-significant positive correlation (r = 0.0435), but it exhibited a negatively moderate direct effect (-0.2111) on *H. armigera* population. It also exhibited negatively moderate (-0.3891) and low (-0.0215) indirect influence on *H. armigera* population through maximum temperature and evaporation, respectively. Whereas, positive moderate (0.3525) and low indirect effect (0.1849, 0.1000 and 0.0278) exhibited through morning relative humidity, wind speed, bright sunshine hours and minimum temperature, respectively on population build-up of *H. armigera*.

Effect of bright sunshine hours on population build-up of *H. armigera*

The bright sunshine hours having a non-significant negative correlation (r = -0.0285), it also exhibited negatively moderate direct effect (-0.1653) on population build-up of *H. armigera*. It exerted positively low indirect influence through evening relative humidity (0.1277), maximum temperature (0.0990) and evaporation (0.0531). Whereas, negatively low indirect effect (-0.0413, -0.0386, -0.0234) exhibited through morning relative humidity, wind speed and minimum temperature, respectively on population fluctuation in *H. armigera* on chickpea.

Effect of wind speed on population build-up of *H. armigera*

The wind speed having a positively non-significant association (r = 0.0830) but it exhibited negative and moderate direct effect (-0.2807) on *H. armigera* population. The negative high indirect influence was also found through morning relative humidity (-0.3737) and found low bright sunshine hours (-0.0227) and minimum temperature (-0.0183). It exerted positive high (0.6218) and low (0.1319 and 0.0176) indirect effect through maximum temperature, evening relative humidity and evaporation respectively, on population build-up of chickpea pod borer.

Effect of evaporation on population build-up of *H. armigera*

The evaporation showing a significant negative association (r = -0.5781*) with *H. armigera* population but it exhibited positive and low direct effect (0.0307) on *H. armigera* population. It exerted negative moderate (-0.2649 and -0.2562) and low (-0.1614,-0.0732 and -0.0010) indirect influence through maximum temperature, morning relative humidity, wind speed, bright sunshine hour and minimum temperature, respectively whereas, positive and low indirect effect (0.1479) was found through evening relative humidity on population build-up of *H. armigera*.

Effect of abiotic parameters on population build-up of *H. armigera*

Residual value presented in [Table-1] indicated that all abiotic factors had a total combined effect of 71.40 per cent on population build-up of *H. armigera*. It indicated that only 28.60 per cent effect was through other unknown factors existing in the ecosystem.

Effect of abiotic factors on *H. armigera* (*Rabi*, 2012-13)

The data presented in [Table-2] indicated the direct and indirect effect of various abiotic factors on population build-up of gram pod borer during *rabi* season of 2012-13.

Effect of maximum temperature on population build-up of *H. armigera*

The maximum temperature exhibited non-significant negative correlation (r = -0.3094) with *H. armigera* population, it also exerted negatively low direct

effect (-0.0017) on *H. armigera* population. Indirect effect of minimum temperature and morning relative humidity were found high and negative (-0.3659 and -0.3036). The indirect effect of bright sunshine hours showed negatively low (-0.0255) on population of *H. armigera*. Positively low indirect effect was observed through wind speed (0.1841), evening relative humidity (0.1691) and evaporation (0.0341) on population build-up of *H. armigera*.

Table-1 *Direct and indirect effect of abiotic factors on population build-up of H. armigera in chickpea rabi, 2011-12*

Biotic and abiotic factors	Temperature (°C)		Relative humidity (%)		Bright sunshine hours	Wind speed (km/hr)	Evaporation (mm)	Correlation with *H. armigera* population
	Maximum	Minimum	Morning	Evening				
Maximum temperature	**-1.1428**	0.0349	0.1872	-0.0719	0.0143	0.1527	0.0071	**-0.8184****
Minimum temperature	-0.8909	**0.0448**	0.1480	-0.1312	0.0864	0.1145	-0.0007	**-0.6290***
Morning relative humidity	-0.4419	0.0137	**0.4842**	-0.1537	0.0141	0.2167	-0.0162	0.1169
Evening relative humidity	-0.3891	0.0278	0.3525	**-0.2111**	0.1000	0.1849	-0.0215	0.0435
Bright sunshine hours	0.0990	-0.0234	-0.0413	0.1277	**-0.1653**	-0.0386	0.0136	-0.0285
Wind speed (km/hr)	0.6218	-0.0183	-0.3737	0.1391	-0.0227	**-0.2807**	0.0176	0.0830
Evaporation (mm)	-0.2649	-0.0010	-0.2562	0.1479	-0.0732	-0.1614	**0.0307**	**-0.5781***

* Significant at 5 per cent level (r = 0.514)

** Significant at 1 per cent level (r = 0.641) **Residual =0.2860** **R^2=0.9182**

Table-2 *Direct and indirect effect of abiotic factors on population build-up of H. armigera in chickpea rabi, 2012-13*

Biotic and abiotic factors	Temperature (°C)		Relative humidity (%)		Bright sunshine hours	Wind speed (km/hr)	Evaporation (mm)	Correlation with *H. armigera* population
	Maximum	Minimum	Morning	Evening				
Maximum temperature	**-0.0017**	-0.3659	-0.3036	0.1691	-0.0255	0.1841	0.0341	-0.3094
Minimum temperature	-0.0011	**-0.5537**	-0.2738	0.3778	-0.0082	0.0487	0.1095	-0.3008
Morning relative humidity	-0.0005	-0.1592	**-0.9521**	0.8204	0.0539	0.2088	0.1872	0.1585
Evening relative humidity	-0.0003	-0.2194	-0.8193	**0.9534**	0.0748	0.1527	0.2225	0.3644
Bright sunshine hours	-0.0003	-0.0337	0.3831	-0.5328	**-0.1339**	-0.0043	-0.1435	-0.4655
Wind speed (km/hr)	0.0007	0.0609	0.4493	-0.329	-0.0013	**-0.4425**	-0.0787	-0.3407
Evaporation (mm)	0.0002	0.2241	0.6588	-0.784	-0.071	-0.1288	**-0.2706**	-0.3713

* Significant at 5 per cent level (r = 0.514)

** Significant at 1 per cent level (r = 0.641) **Residual = 0.5682** **R^2= 0.6772**

Effect of minimum temperature on population build-up of *H. armigera*

The minimum temperature exhibited non-significant negative association (r = -0.3008) with *H. armigera* population, it also exerted negatively moderate direct effect (-0.5537) on *H. armigera* population. The evening relative humidity showed positive high indirect effect (0.3778) whereas, evaporation (0.1095) and wind speed (0.0487) exhibited positive and low indirect effect on *H. armigera* population. However, morning relative humidity (-0.2738) showed moderate and bright sunshine hours (-0.0082) and maximum temperature (-0.0011) showed negatively low indirect influence on population fluctuation of *H. armigera*

Effect of morning relative humidity on population build-up of *H. armigera*

The morning relative humidity had a non significant positive association (r = 0.1585) with *H. armigera* population but its direct effect on *H. armigera* population build-up was found negatively high (-0.9521). This parameter exerted positively high (0.8204) and low (0.2088, 0.1872 and 0.0539) indirect influence through evening relative humidity, wind speed, evaporation and bright sunshine hours respectively, while, negatively low indirect effect were found through minimum temperature (-0.1592) and maximum temperature (-0.0005) on population build-up of *H. armigera*.

Effect of evening relative humidity on population build-up of *H. armigera*

The evening relative humidity having a non-significant positive correlation (r = 0.3644), it also exhibited a positive high direct effect (0.9534) on *H. armigera* population. Its positive moderate (0.2225) and low (0.1527 and 0.0748) indirect influence were found through evaporation, wind speed and bright sunshine hours, respectively whereas, negative high (-0.8193), moderate (-0.2194) and low (0.0003) indirect effect were exhibited through morning relative humidity, minimum temperature and maximum temperature, respectively, on population fluctuation of *H. armigera*.

Effect of mean bright sunshine hours on population build-up of *H. armigera*

The mean bright sunshine hours having a non-significant negative correlation (r = -0.4655), it also exhibited low negative direct effect (-0.1339) on population build-up of *H. armigera*. It exerted positively moderate indirect influence through morning relative humidity (0.3831) while, negatively moderate (-0.5328) and low indirect effect (-0.1435, -0.0337, -0.0043 and -0.0003) were exhibited through evening relative humidity, evaporation, minimum temperature, wind speed and maximum temperature, respectively on population fluctuation of *H. armigera*.

Effect of wind speed on population build-up of *H. armigera*

The wind speed having a non-significant negative association (r = -0.3407) it also showed negatively high direct effect (-0.4425) on *H. armigera* population. The morning relative humidity showed highly positive indirect impact (0.4493) while, evening relative humidity exhibited highly negative (-0.3290) indirect influence on population of *H. armigera*. The indirect effect of evaporation (-0.0797) and bright sunshine hours (-0.0013) was found negatively low whereas, minimum temperature (0.0609) and maximum temperature (0.0007) exerted positively low indirect influence on population build-up of *H. armigera*.

Effect of evaporation on population build-up of *H. armigera*

The evaporation exerted a non-significant negative association (r= -0.3713), it also exhibited negative moderate direct effect (-0.2706) on *H. armigera* population. This parameter exhorted positively high (0.6588), moderate (0.2241) and low (0.0002) indirect influence through morning relative humidity, minimum temperature and maximum temperature, respectively. While, negatively high (-0.7840) and low (-0.1288 and -0.0710) indirect effect were found through evening relative humidity, wind speed and bright sunshine hours respectively, on population build-up of *H. armigera*.

Effect of abiotic parameters on population build-up of *H. armigera*

Residual value presented in [Table-2] indicated that all these abiotic factors had a total combined effect of 43.18 per cent on population build-up of *H. armigera*. It indicated that 56.82 per cent effect was through other unknown factors existing in the ecosystem. It clearly showed that weather parameters contributed only 43.18 per cent effect on population build-up of *H. armigera* during *rabi,* 2012-13.

It was concluded from the experimental results that all abiotic factors had a total combined effect of 43 to 71 per cent on population build-up of *H. armigera*. It indicated that 57 to 29 per cent effect was through other unknown factors existing in the ecosystem.

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