PLANT SCIENCE TODAY
Vol 12(sp1): 01–05
https://doi.org/10.14719/pst.9246

eISSN 2348-1900

RESEARCH ARTICLE

The effect of abiotic factors on incidence of major insect pests in cowpea [*Vigna unguiculata* (L.) Walp.]

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Received: 02 May 2025; Accepted: 21 July 2025; Available online: Version 1.0: 25 September 2025

Cite this article: Ram NS, Bhanwar LJ, Sharad KM, Bablu S, Arti S, Pradeep KK. The effect of abiotic factors on incidence of major insect pests in cowpea [*Vigna unguiculata* (L.) Walp.]. Plant Science Today. 2025;12(sp1):01–05. https://doi.org/10.14719/pst.9246

Abstract

Understanding the impact of abiotic factors on pest incidence in cowpea is crucial for developing effective pest management strategies. By identifying how environmental conditions influence pest populations, farmers can better anticipate outbreaks and implement timely interventions. To analyze the seasonal incidence of major insect pests on cowpea, a simple correlation analysis was conducted between pest populations and abiotic factors, including minimum and maximum temperatures, morning and evening relative humidity, rainfall and wind speed. Field experiments were conducted at the Rajasthan Agricultural Research Institute (RARI), Durgapura, Jaipur (Rajasthan), during two consecutive seasons *i.e., Kharif* 2022 and 2023. During *Kharif* 2022, jassids and whiteflies exhibit a positive correlation with maximum temperature (r = 0.668 and 0.670, respectively) and negative correlations with relative humidity, while *Maruca vitrata* was also positively correlated with temperature (r = 0.673). In 2023, similar trends were observed, with significant negative correlations between jassids, whiteflies and *M. vitrata* populations and relative humidity, while *M. vitrata* again showed a positive correlation with temperature (r = 0.669). The study concludes that temperature positively influences the population buildup of jassids, whiteflies and *M. vitrata*, while relative humidity has a suppressive effect. These findings highlight the importance of incorporating weather-based forecasting in pest management strategies for cowpea.

Keywords: cowpea; pests; significant; SMW

Introduction

Cowpea [*Vigna unguiculata* (L.) Walp.] is a vital legume crop cultivated in tropical and subtropical regions for both vegetable and pulse production. It is severely damaged by aphids, jassids, whiteflies, thrips and pod borer (*M. vitrata* Fab.), resulting in heavy yield losses (1). Jassids and whiteflies are sap-feeding insect of cowpea that significantly reduce plant growth during the initial establishment phase. Severe infestations lead to leaf cupping, while in extreme cases, cupping is accompanied by yellowing and bronzing of leaves. The pod borer (*M. vitrata*) is one of the most damaging pests, particularly during the flower bud and post-flowering stages of cowpea development (2). Deformation or direct damage to the floral parts negatively affects yield. After pod formation, the borer scrapes and bores into the pods, feeding on the seeds inside and causing direct pod damage.

Previous studies have documented individual pest impacts on cowpea, but limited research has addressed their population dynamics in relation to fluctuating weather patterns. This study aims to fill that gap by analyzing how key abiotic factors influence multiple pest species across seasons. The present study was undertaken to examine how weather parameters-such as temperature, relative humidity, rainfall distribution and intensity and wind speed-influence the infestation and population dynamics of various insect pests in cowpea. Accordingly, efforts were made to determine the relationship between pests populations and these abiotic factors.

Materials and Methods

Field experimentation

To study the seasonal incidence of major insect pests of cowpea, five separate plots measuring 1.2 × 3.0 m^2 were established at the experimental field. A spacing of 30 cm (row-to-row) and 10 cm (plant-to-plant) was maintained. The cowpea variety CPD-119 (source: Rajasthan Agricultural Research Institute, Durgapura, Jaipur, Rajasthan) was sown on July 12, 2022 and July 10, 2023 and harvested during the last week of September in both years. Standard agronomic practices were followed, except for plant protection measures, which were deliberately omitted to allow natural infestation by insect pests.

Insect pest observation

Weekly observations were recorded on the following pests namely, jassid, whitefly and spotted pod borer (*M. vitrata).*

Observations were taken on five randomly selected and permanently tagged plants per plot. Jassid and whitefly populations (both nymphs and adults) were counted on three leaves per plant (top, middle and bottom canopy) during early morning hours. The larval population of *M. vitrata* was recorded from its first appearance until crop maturity.

Statistical analysis

To interpret the seasonal incidence of insect pests, the following statistical analyses were carried out.

Simple correlation analysis was performed between pest population and abiotic factors, including, maximum temperature (X_1), minimum temperature (X_2), morning relative humidity (X_3), evening relative humidity (X_4), rainfall (X_5) and wind speed (X_6).

The combined effect of abiotic factors on pest population was evaluated using stepwise multiple linear regression analysis, represented by the equation:

$$Y = a + b_1X_1 + b_2X_2 + b_3X_3 + ... + b_nX_n + e \quad \text{(Eqn. 1)}$$

Where, Y = pest population (dependent variable), a = intercept (constant), $b_1, b_2, \ldots, b_n$ = regression coefficients for each independent variable. $X_1, X_2, \ldots, X_n$ = abiotic factors (independent variables) and e = random error term

Results and Discussion

Jassid, *Empoasca fabae* (Harris)

The infestation of jassids commenced in the 31st SMW (standard meteorological week) with a population of 0.92 jassids per three leaves during *Kharif* 2022 and in the 30th SMW with a population of 1.24 jassids per three leaves during *Kharif* 2023 (Table 1, 2; Fig. 1, 2). The jassid population gradually increased, reaching its peak in the 35th SMW with 11.32 jassids per three leaves during *Kharif* 2022 and in the 34th SMW with 12.86 jassids per three leaves during *Kharif* 2023. The present findings are consistent with the earlier reports indicating that the incidence of leafhopper on cowpea begins around the 31st SMW, with peak population observed during the 35th SMW (3-6).

The correlation analysis revealed that during *Kharif* 2022, the jassid population exhibited a significant positive correlation with maximum temperature (r = 0.668) and a significant negative correlation with evening relative humidity (r = -0.698) (Table 3). In *Kharif* 2023, a significant negative correlation was observed between jassid population and morning relative humidity (r = -0.667). These findings are consistent with earlier reports indicating a positive correlation between jassid population and maximum temperature and a negative correlation with evening relative humidity (7). Similarly, other studies have reported a positive association with maximum temperature and a negative correlation with morning relative humidity (8). The present results also align with previous findings where jassid population showed a significant positive correlation with maximum temperature (4, 6).

The multiple linear regression analysis explained 80 % and 84 % of the variation in jassid population due to the combined influence of abiotic factors during 2022 and 2023, respectively (Table 4). Stepwise regression analysis indicated that evening relative humidity alone accounted for 49 % of the significant variation in jassid population in 2022 (Table 5). In 2023, morning relative humidity and rainfall together explained 74 % of the significant variation in jassid population.

Whitefly, *Bemisia tabaci* (Genn.)

The incidence of whitefly commenced in the 31st SMW with a population 1.96 whiteflies per three leaves during *Kharif* 2022 and 30th SMW with a population of 1.56 whiteflies per three leaves during *Kharif* 2023 (Table 1, 2; Fig. 1, 2). The incidence of whitefly gradually increased, reaching its peak in the 34th SMW with 8.24 whiteflies per three leaves during *Kharif* 2022 and 33rd SMW with 10.56 whiteflies per three leaves during *Kharif* 2023. The findings are supported by observations showing that whitefly infestation on cowpea began in the 31st SMW, with peak population recorded during the 35th SMW (3, 5-6).

The correlation studies revealed that the whitefly population showed significant positive correlation with maximum

Table 1. Seasonal incidence of major insect pests of cowpea in relation to abiotic factors during *Kharif* 2022.

S. No.	SMW*	Date of observation	Temperature (°C)		Relative humidity (%)		Total rainfall (mm)	Wind speed (Kmph)	Jassids/ 3 leaves	Whiteflies/ 3 leaves	Larvae of *M. vitrata*/ plant
			Maximum	Minimum	Morning	Evening					
1	31	31/07/2022	32.4	25	89	70	55.6	4.1	0.92	1.96	0
2	32	07/08/2022	31.4	23.4	93	70	90.4	6.2	1.84	2.52	0
3	33	14/08/2022	29.6	23.2	93	76	88.2	6.7	3.04	4.04	0.28
4	34	21/08/2022	33.6	24.9	75	57	14.6	7	7.44	8.24	0.68
5	35	28/08/2022	33.2	25.2	85	59	20.2	4.2	11.32	7.80	2.04
6	36	04/09/2022	33.3	25.1	82	65	24	3.2	8.04	7.16	3.00
7	37	11/09/2022	35.1	25.3	81	53	37.8	4.8	7.76	6.76	2.56
8	38	18/09/2022	33	22.1	85	58	21.5	5.2	5.64	4.84	1.68
9	39	25/09/2022	31	22.4	86	65	22.2	5.9	2.04	1.44	0.84

SMW*- standard meteorological week.

Table 2. Seasonal incidence of major insect pests of cowpea in relation to abiotic factors during *Kharif* 2023.

S. No.	SMW*	Date of observation	Temperature (°C)		Relative humidity (%)		Total rainfall (mm)	Wind speed (Kmph)	Jassids/ 3 leaves	Whiteflies/ 3 leaves	Larvae of *M. vitrata*/ plant
			Maximum	Minimum	Morning	Evening					
1.	30	28/07/2023	30.6	24.9	87	72.8	43	6.6	1.24	1.56	0
2.	31	04/08/2023	30.5	23.5	90.8	70.1	51.5	6.2	3.08	4.04	0
3.	32	11/08/2023	32.2	23.5	80	62.2	0	8	5.56	6.96	0.44
4.	33	18/08/2023	33.6	24	78	63.2	3.5	6.6	9.56	10.56	1.04
5.	34	25/08/2023	32.5	24.2	83	66	69	4.9	12.86	9.08	2.08
6.	35	01/09/2023	33.1	23.4	74.7	58.4	4	6.2	8.16	7.96	3.24
7.	36	08/09/2023	34.7	22.4	81.1	58.5	7	6.5	5.08	4.84	2.76
8.	37	15/09/2023	32.2	23	84.7	64	45	5.4	3.86	3.08	2.12
9.	38	22/09/2023	33.9	22	88.1	63.4	21.5	6	2.48	2.36	1.24

SMW*- standard meteorological week.

Table 3. The correlation coefficient (r) between abiotic factors and major insect pests on cowpea crop during *Kharif* 2022 and 2023.

S. No.	Abiotic factors	2022			2023		
		Jassid	Whitefly	*M. vitrata*	Jassid	Whitefly	*M. vitrata*
1	Maximum temperature (°C)	0.668*	0.670*	0.673*	0.349(NS)	0.328(NS)	0.669*
2	Minimum temperature (°C)	0.529(NS)	0.598(NS)	0.361(NS)	0.260(NS)	0.264(NS)	-0.407(NS)
3	Morning relative humidity (%)	-0.644(NS)	-0.732*	-0.535(NS)	-0.667*	-0.737*	-0.601(NS)
4	Evening relative humidity (%)	-0.698*	-0.644(NS)	-0.628(NS)	-0.403(NS)	-0.425(NS)	-0.777*
5	Total rainfall (mm)	-0.619(NS)	-0.527(NS)	-0.605(NS)	-0.027(NS)	-0.274(NS)	-0.205(NS)
6	Wind speed (Kmph)	-0.353(NS)	0.186(NS)	-0.641(NS)	-0.254(NS)	0.033(NS)	-0.424(NS)

***Significant at 5 % level, **NS** = non-significant.

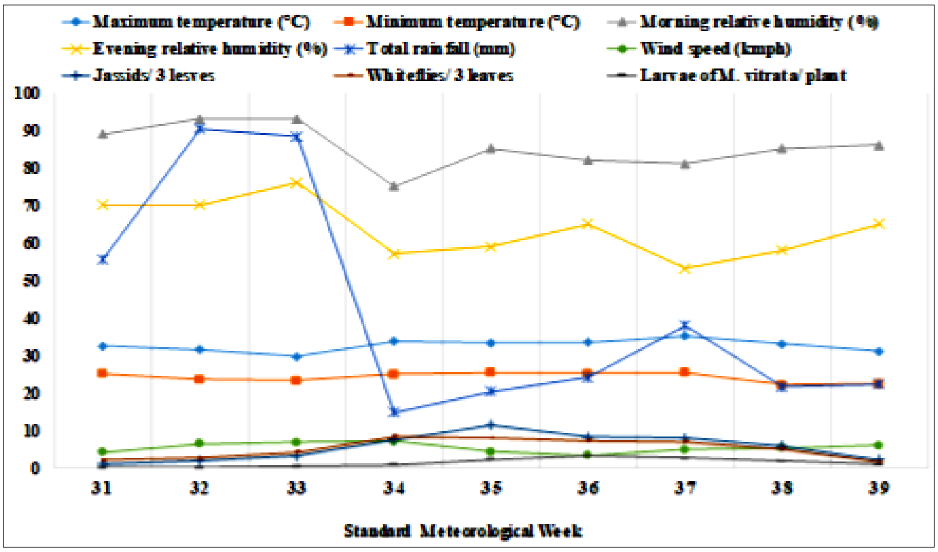

Fig. 1. Seasonal incidence of major insect pests of cowpea in relation to abiotic factors during *Kharif* 2022.

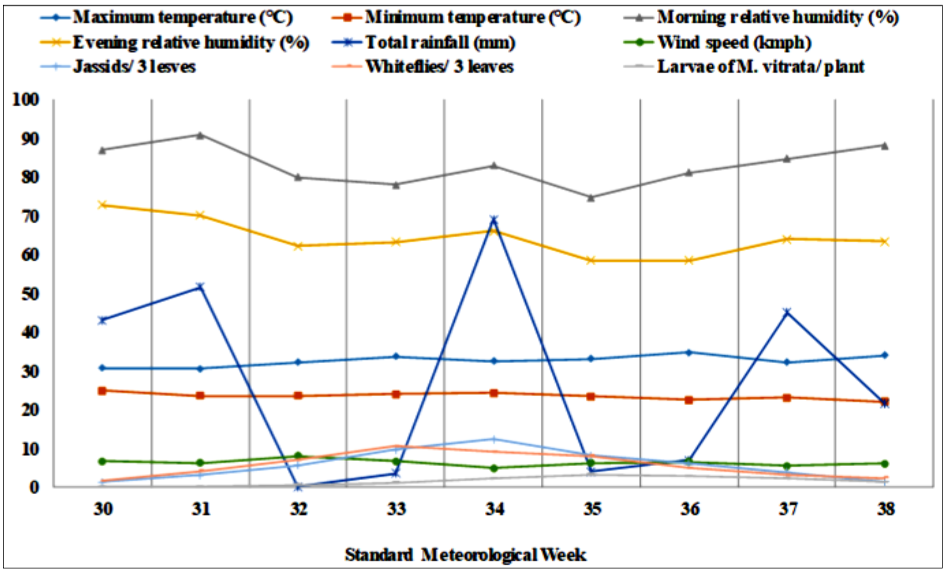

Fig. 2. Seasonal incidence of major insect pests of cowpea in relation to abiotic factors during *Kharif* 2023.

Table 4. Multiple linear regression models developed for major insect pests on cowpea crop during *Kharif* 2022 and 2023.

S. No.		Multiple linear regression equation ($Y = a + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + b_6X_6$) 2022	2023	R^2 value 2022	2023
1.	Jassid	$Y = 356.79^a + (-6.69)\ T_{max} + (1.63)\ T_{min} + (-0.84)\ RH_{mor} + (-1.40)\ RH_{eve} + (0.17)\ RF + (-3.61)\ WS$	$Y = -107.13^a + (1.34)\ T_{max} + (5.07)\ T_{min} + (0.20)\ RH_{mor} + (-1.14)\ RH_{eve} + (0.12)\ RF + (0.69)\ WS$	0.80	0.84
2.	Whitefly	$Y = 237.03^a + (-3.92)\ T_{max} + (0.88)\ T_{min} + (-0.83)\ RH_{mor} + (-0.77)\ RH_{eve} + (0.14)\ RF + (-2.18)\ WS$	$Y = -0.52^a + (1.03)\ T_{max} + (0.30)\ T_{min} + (-0.65)\ RH_{mor} + (0.13)\ RH_{eve} + (0.10)\ RF + (1.33)\ WS$	0.75	0.67
3.	*M. vitrata*	$Y = 183.12^a + (-2.67)\ T_{max} + (-0.24)\ T_{min} + (-0.57)\ RH_{mor} + (-0.52)\ RH_{eve} + (0.11)\ RF + (-2.28)\ WS$	$Y = -41.17^a + (-0.41)\ T_{max} + (3.39)\ T_{min} + (0.68)\ RH_{mor} + (-1.04)\ RH_{eve} + (-0.06)\ RF + (-1.77)\ WS$	0.98	0.94

T_{max}- maximum temperature, **T_{min}** - minimum temperature, **RH_{mor}** – morning relative humidity, **RH_{eve}** – evening relative humidity, **RF** – rainfall and **WS** – wind speed.

Table 5. The step wise regression models developed for major insect pests on cowpea crop during *Kharif* 2022 and 2023.

S. No.		Step wise regression equation (Y = a + bX)		R^2 value	
		2022	2023	2022	2023
1.	Jassid	Y= 26.48[a] + (-0.33) RH_{eve}	Y= 71.13[a] + (-0.82) RH_{mor}+ (0.11) RF	0.49	0.74
2.	Whitefly	Y= 33.34[a] + (-0.33) RH_{mor}	Y= 43.23[a] + (-0.45) RH_{mor}	0.54	0.54
3.	*M. vitrata*	Y= -13.90[a] + (0.47) T_{max}	Y= 19.48[a] + (-0.21) RH_{eve} + (-0.73) WS	0.45	0.89

T_{max}- maximum temperature, **T_{min}** - minimum temperature, **RH_{mor}** – morning relative humidity, **RH_{eve}** – evening relative humidity.

temperature (r = 0.670) and significant negative correlation with morning relative humidity (r = -0.732) during *Kharif* 2022 (Table 3). In *Kharif* 2023, the whitefly population exhibited a significant negative correlation with morning relative humidity (r = -0.737). The results conform with the whitefly population on mungbean showed a positive correlation with maximum temperature and negative correlation with morning relative humidity (9). The present findings are conformity with the maximum temperature showed positive significant correlation with whitefly population (6, 10, 11). Similar, the whitefly population on green gram showed a negative correlation with morning relative humidity (8). The results also corroborate with the population of whitefly had a significant negative correlation with morning relative humidity (12).

The multiple linear regression analysis explained 75 % and 67 % of the variation in whitefly population due to the combined influence of abiotic factors during 2022 and 2023, respectively (Table 4). The step wise regression analysis explained, among the abiotic factors, morning relative humidity accounted 54 % significant variation in whitefly population during *Kharif* 2022 and 54 % significant variation in whitefly population due to morning relative humidity during *Kharif* 2023.

Spotted pod borer, *Maruca vitrata* (Fabricius)

The incidence of *M. vitrata* began in the 33rd SMW with 0.28 larvae per plant during *Kharif* 2022 and the 32nd SMW with 0.44 larvae per plant during *Kharif* 2023 (Table 1, 2; Fig. 1, 2). The incidence of *M. vitrata* gradually increased, reaching its peak in the 36th SMW with 3.0 larvae per plant during *Kharif* 2022 and 35th SMW with 3.24 larvae per plant during *Kharif* 2023. The present results are consistent with observations that *M. vitrata* infestation on cowpea began in the 34th SMW, with peak population recorded in the 36th SMW (13-15).

There is slight variation in the commencement and peak period of jassid, whitefly and *M. vitrata* incidence is likely due to differences in the crop's sowing time and the varying agro-climatic conditions of the locality.

The correlation analysis revealed that the *M. vitrata* population exhibited a significant positive correlation with maximum temperature (r = 0.673) during *Kharif* 2022 (Table 3). In *Kharif* 2023, the *M. vitrata* population showed a significant positive correlation with maximum temperature (r = 0.669) and a significant negative correlation with evening relative humidity (r = -0.777). This study is conformity with the population of *M. vitrata* showed significant positive correlation with maximum temperature (13-14). The results also corroborate with the population of spotted pod borer had significant negative correlation with evening relative humidity (10, 16).

The multiple linear regression analysis explained 98 % and 94 % of the variation in *M. vitrata* population due to the combined influence of abiotic factors during *Kharif* 2022 and 2023, respectively (Table 4). The step wise regression analysis explained, among the abiotic factors, maximum temperature accounted 45 % significant variation in *M. vitrata* population during *Kharif* 2022 and 89 % significant variation in *M. vitrata* population due to evening relative humidity and wind speed during *Kharif*, 2023.

Conclusion

The incidence of jassid and whitefly started in the last week of July (31st SMW) during *Kharif* 2022 and the fourth week of July (30th SMW) during *Kharif* 2023. The population of jassid and whitefly gradually increased and reached to its peak in the fourth week of August and third week of August in both the year. The incidence of *M. vitrata* began in the second week of August and reached to its peak in the first week of September in both the year. Abiotic factors emerged as a key influence on pest populations. Different factors such as temperature, humidity, rainfall and wind speed showed varying impacts. These impacts were inconsistent across different pests and years. The multiple linear regression analysis revealed that abiotic factors significantly influenced the variation in populations of insect pests on the cowpea crop. Future research could explore the interactive effects of biotic and abiotic factors on pest dynamics across multiple agro-climatic zones. Additionally, predictive modeling using long-term climatic data could enhance early warning systems for pest outbreaks in cowpea cultivation.

Acknowledgements

The authors are thankful to the Head, Department of Entomology, Rajasthan Agricultural Research Institute (RARI), Durgapura, Jaipur (Rajasthan) for providing facilities to carry out the present study.

Authors' contributions

RNS wrote the first draft of the paper. BLJ and SKM conceptualized, reviewed and edited the manuscript. BS, AS and PKK reviewed the paper and shared their inputs for upscaling. All authors read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interest to declare.

Ethical issues: None.

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work the authors used ChatGPT to grammar check, improve readability, rephrasing text etc. After using this tool/service, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

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Peer review: Publisher thanks Sectional Editor and the other anonymous reviewers for their contribution to the peer review of this work.

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