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Assessment of the Incidence of Pigeon Pea Leaf Webber, *Grapholita critica* (Meyr.) and Roller, *Caloptilia soyella* (Van.) in Relation to Weather Variables in the Bundelkhand Region of Uttar Pradesh

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ABSTRACT

Background: Pigeon pea (*Cajanus cajan*, Mayer) is the member of Asian *Cajanus* crop and also reffered as Tur and Arhar and commonly grown in *Kharif* session in Indian subcontinent.). In India, around 250 known species of insect pests have been identified to affect pigeon pea crops at different growth stages. The leaf webber and leaf roller are notable insect pests that pose a significant threat to pigeonpea, particularly during its vegetative stage. The leaf webber and leaf roller, among various insect pests, are notably visible and pose a threat to pigeonpea. These insects target the pigeonpea plant during its vegetative stage. Specifically, the leaf webber, identified as *Grapholita (Pammene) critica,* Meyrick (Lepidoptera: Tortricidae), has been acknowledged as a significant constraint affecting pigeonpea production. The aim of this investigation is to assess the relationship between the incidence of leaf roller and leaf webber and various abiotic factors, including temperature, relative humidity, wind velocity and rainfall.

Methods: The research, spanning *Kharif* 2021-22 and 2022-23, at Entomological Research Block in BUAT, Banda. It aimed to observe leaf roller and leaf webber incidence in pigeon pea alongside weather conditions. 'IPA-203' pigeon pea variety was manually sown in 200 m^2 plots on July 12, 2021 (first year) and July 18, 2022 (second year). Standard agronomic practices were adhered to and no insecticides were used on the crop.

Result: Over the two-year observation period, the larval population of *G. critica* on pigeon pea plants commenced during the 34th SMW, peaking at 4.90 larvae plant^{-1} in the 45th SMW. Simultaneously, *C. soyella* infestation initiated in the 34th SMW, steadily increasing until the 42nd SMW, reaching its peak larval count at 3.03.

Key words: Correlation studies, Leaf roller, Leaf webber, Pigeon pea, Weather variables.

INTRODUCTION

Pigeon pea, scientifically known as *Cajanus cajan*, L. (Mill.) is a significant pulse crop and it is commonly referred to as Red gram, Arhar, or Tur, cultivated across several countries throughout the tropics and subtropics (Sarkar *et al*., 2018). The origin of pigeonpea is believed to Asia. This crop serves as a vital source of protein, contributing approximately 22% to the human diet, which is nearly three times the protein content found in cereals. It contains lysine, riboflavin, thiamine, niacin and iron in particular (Singh and Yadav, 2005). It is highly preferred pulse crop in arid regions where it is commonly intercropped or incorporated into mixed cropping systems alongside cereals or other short-lived annual plants without causing a substantial decrease in overall yield (Joshi *et al*., 2001). India is the primary producer, achieved a pigeon pea yield of 4.34 million tonnes from a cultivated area of 5.05 million hectares, attaining a productivity of 859 kg/ha (Anonymous, 2022). According to Tiwari and Shivhare (2016), the country with the highest observed production was Israel, with a yield of 6120 kg per hectare. Yemen, Canada and Egypt also had very high productivity, while India had a comparatively lower yield of 920 kg/ha. Despite being the greatest producer of pigeonpea, India's productivity in this crop has consistently been a matter of biotic concern.

Infestation of various defoliating insect pests have been reported as a problem in various fabaceous crops like

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pigeon pea (Basandrai *et al*., 2011) and soybean (Motaphale and Bhosle, 2016) in last three to four decades. In India, there are about 250 identified species of insect pests that are known to infest pigeonpea crops at different stages of growth (Gopali *et al*., 2010). Among the various insect pests, the leaf webber and leaf roller are particularly noticeable and pose a threat to pigeonpea. These insects target the pigeonpea plant throughout its vegetative stage. Leaf webber, *Grapholita* (*Pammene*) *critica* Meyrick (Lepidoptera: Tortricidae), has been identified as a significant constraint on its production (Singh and Cheema, 2006). The larval stage of *G. critica* mostly consumes plant foliage, buds, flowers and occasionally pods (Fig 1). During the vegetative stage, larvae induce harm by webbing terminal leaves through the utilisation of silken threads, subsequently consuming chlorophyll which affect the photosynthesis. Leaf roller, *Caloptilia soyella* (Gracillariidae: Lepidoptera), inflict damage by feeding on and rolling up pigeon pea leaves, leading to reduced photosynthesis, stunted growth and potential yield losses (Fig 2). Effective pest management is crucial for mitigating their damaging impact on crops. The symptoms associated with infestation are highly noticeable and studies have indicated that under controlled condition, a larval population of 10 plant^{-1} resulted in a yield loss of approximately 5.7% (Kumar *et al*., 2014). While the primary period of harm caused by the larva occurs during the vegetative stage, there are instances where its impact might extend to the reproductive stage, resulting in injury to the flowers and pods.

The leaf webber, identified as a minor pest in certain pigeon pea cultivation regions by Narendra *et al.* (1998), while Akhilesh and Nath (2003) and Sinam and Singh (2004) highlight its potential transition to a major threat due to significant damage.

The role of weather in determining the geographical distribution and periodic abundance of insect pests is noteworthy. Proper quantification of the relationship between insect pests and weather conditions enables the prediction of impending damage and facilitates the improvement of integrated pest management (IPM) strategies (Vennila *et al*., 2019; Seni and Naik, 2018; Seni, 2020). In this study, an effort was undertaken to examine the impact of different meteorological conditions on the occurrence of leaf webber and leaf roller of pigeonpea in the Bundelkhand region of Uttar Pradesh, India.

MATERIALS AND METHODS

Study area

Field experiment was conducted at Entomological research block, Banda University of Agricultureand Technology, Banda during *Kharif* season of 2021-22 and 2022-23. For

Fig 1: Damaging symptom and larva of *G. critica.*

Fig 2: Damaging symptoms of *C. soyella.*

the assessment of incidence of Pigeonpea Leaf Webber *Grapholita critica* (Meyr) and Roller *Caloptilia soyella* (Van.) in Bundelkhand region of Uttar Pradesh. The pigeonpea cultivar IPA-203 was sown in the plot size of 200 m^2 and spacing 60×30 cm. Standard agronomic practices were adopted to raise the crop.

Observation

Observations on the incidence of leaf webber and leaf roller were recorded on 10 randomly selected plants in pesticide free plot at weekly interval from the IPA-203 cultivated plots. The observations were started to take after 30 days of germination to till occurrence of insects. The data on leaf webber was recorded by counting the number of webs with live larva on whole plant basis from 10 randomly selected plants. The peculiar symptom of leaf roller *i.e.*, terminal single folded along with larva was counted from each plant of 10 randomly selected plants The population of leaf roller and leaf webber were correlated with climatic factors *i.e.*, maximum and minimum temperature, morning relative humidity, evening relative humidity, wind velocity and rain fall by using statistical software.

The following formula were used to determine the correlation and regression analysis between insect and weather variables

$$\text{Correlation coefficient (r)}=\frac{\Sigma(X-\bar{X})(Y-\bar{Y})}{\sqrt{\Sigma(X-\bar{X})^2(Y-\bar{Y})^2}}$$

$$\text{Regression coefficient (byx)}=\frac{\Sigma(X-\bar{X})(Y-\bar{Y})}{\sqrt{\Sigma(X-\bar{X})^2}}$$

The regression equations were derived by using following formula as suggested by Panse and Sukhatme (1954).

$$\text{Regression equation}\rightarrow(y-\bar{y})=\text{byx }(x-\bar{x})$$

Where:

X= Independent variables (weather variables).

X= Mean of independent variables.

Y= Dependent variables (insect populations).

Y= Mean of dependent variables.

byx= Regression coefficient of Y on X.

RESULTS AND DISCUSSION

The objective of the study was to analyse the relationship between the occurrence of leaf roller and leaf webber and different abiotic factors, such as temperature, relative humidity, wind velocity and rainfall. Utilizing data collected during the *Kharif* seasons of 2021-22 and 2022-23, a regression equation was framed to elucidate the associations between the population of insect pests and the meteorological variables in Table 1, 2, 3 and 4.

Incidence of *Caloptilia soyella* during *Kharif*, 2021-22

The data regarding incidence of leaf roller (*Caloptilia soyella*) during *kahrif*-2022-22 on pigeonpea was observed in 34th SMW which was steadily increased up to 42nd SMW. The maximum (5.07) larval population was observed in 42nd SMW, at minimum temperature 22.9°C, maximum temperature 33.1°C, morning relative humidity 85.0 per cent, evening relative humidity 59.3., wind velocity 4.9 and rainfall 7.0 mm, whereas it was minimum 0.37 in 47th SMW at minimum temperature 14.6°C, maximum temperature 29.3°C, morning relative humidity 78.7 per cent, evening relative humidity 45.7, wind velocity 2.3 and rainfall 0.0 mm. Thus, larval population during the entire period ranged from 0.37 to 5.07 larvae plant^{-1} (Table1).

Incidence of *Caloptilia soyella* during *Kharif*, 2022-23

Similarly, first incidence of leaf roller on pigeonpea was observed in 35th standard week during Kharif-2022-23 which was gradually increased up to 41st SMW. The highest (1.83) larval population was observed in 41st SMW, at minimum temperature 24.3°C, maximum temperature 33.0°C, morning relative humidity 93.1 per cent, evening relative humidity 70.9, wind velocity 2.8 and rainfall 10.02 mm, whereas it was minimum 0.23 in 48th SMW at minimum temperature 13.5°C, maximum temperature 27.8°C, morning relative humidity 86.0 per cent, evening relative humidity 53.7, wind velocity 2.5 and rainfall 00 mm. Thus, larval population during the entire period ranged from 0.23 to 1.83 larvae plant^{-1} (Table 3).

Kumar and Naika (2019) recorded maximum population of leaf roller (3.36 larvae plant^{-1}) during October month which are more or less similar to current study. Documentation on seasonal incidence of leaf roller in Bundelkhand region is not available. Keeping in view the larval population and leaf folding behaviour by the larvae, further studies are required of this pest in this region.

Correlation between larval population of *Caloptilia soyella* and weather parameters during *Kharif*, 2021-22 and 2022-23

The correlation study conducted during the *Kharif* of 2021-22 for leaf roller (Table 2) showed a substantial positive correlation with maximum temperature (0.505), while minimum temperature (0.361), morning humidity (0.288), evening humidity (0.139), wind velocity (0.185) and rainfall (0.198) showed non-significant positive correlations.

The correlation study for the leaf roller was obtained as highly significant positive correlations with the maximum temperature (0.626), whereas the minimum temperature (0.581), morning humidity (0.541) and rainfall (0.485) showed significant positive correlations. However, there were no significant correlations observed with evening humidity (0.402) and wind velocity (0.001) during *Kharif* 2022–23 (Table 4).

Kumar and Naika (2019) studied on correlation studies on incidence of leaf roller, *Diaphania pulverulentalis* (Hampson) in mulberry and stated that minimum temperature and rainfall significant positively correlated with leaf roller population and recorded correlated value 0.541 and 0.844 respectively.

Incidence of *Grapholita critica* during *Kharif*, 2021-22

The occurrence of *Grapholita critica* on pigeonpea during *Kharif*- 2021-22 was first noticed from 35th SMW, which was grew up to 47th SMW. The maximum (4.57 larvae plant^{-1}) population was observed in 47th SMW, at minimum temperature 14.6°C, maximum temperature 29.3°C, morning relative humidity 78.7 per cent, evening relative humidity 45.7, wind velocity 2.7 and rainfall 00, whereas it was minimum 0.20 larvae plant^{-1} in 35th standard week at minimum temperature 27.4°C, maximum temperature 35.7°C, morning relative humidity 89.4 per cent, evening relative humidity 66.4, wind velocity 4.7 and rainfall 2.7mm. Thus, larval population during the entire period ranged from 0.20 to 4.57 larvae plant^{-1} (Table 1).

During 2022-23 the data pertaining to incidence of *G. critica* on pigeonpea shown that the population was first noticed in 35th SMW, which was steadily increased up to 44th SMW. The maximum (6.37 larvae plant^{-1}) larval population was observed in 44th SMW, at minimum temperature 18.9°C, maximum temperature 33.6°C, morning relative humidity 89.0 per cent, evening relative humidity 55.3, wind velocity 1.8 and rainfall 0.0, whereas it was minimum 0.17 in 35th SMW at minimum temperature 27.9°C, maximum temperature 32.4°C, morning relative humidity 93.9 per cent, evening relative humidity 80.6, wind velocity 2.6 and rainfall 7.9 mm. Thus, larval population during the entire period ranged from 0.17 to 6.37 larvae plant^{-1} (Table 1). The current results align with Dwivedi *et al.* (2013), indicating that the pest reached its peak at a maximum temperature of 34.3°C, minimum temperature of 21.20°C and a relative humidity of 65%. The results are in close conformity with the findings of Ambhure (2012), Shinde and Patel (2014) and Chowdhary *et al*. (2020) who observed that leaf webber infest the pigeonpea crop from vegetative stage to reproductive stage of the crop. They also confirm that leaf webber incidence attend its maximum level (4.0 to 5.03 webs plant^{-1}) on 45th to 48th SMW.

Correlation between larval population of *Grapholita critica* and weather parameters during *Kharif*, 2021-22 and 2022-23

Leaf webber exhibited highly substantial negatively correlated with minimum temperature (-0.791), morning humidity (-0.857), evening humidity (-0.839), wind velocity (-0.723) and rainfall (-0.496), while maximum temperature (-0.463) showed non-significant negative correlations during the *kharif* 2021-22 (Table 2).

Table 1: Population of leaf roller and leaf webber infesting pigeonpea 2021-22.

SMW	Mean Number of larva plant^{-1}		Weather					
			Temperature		Relative humidity		W. V.	Rainfall
	roller	webber	Maximum	Minimum	Morning	Evening	(Km./Hr.)	(mm)
34	0.43	0.00	34.4	27.0	91.1	78.4	4.3	2.8
35	0.57	0.20	35.7	27.4	89.4	66.4	4.7	2.7
36	0.90	0.27	34.6	26.6	89.3	68.3	3.6	2.8
37	1.07	0.37	31.7	25.9	91.1	78.3	5.9	12.9
38	2.53	0.57	26.7	34.6	94.4	80.7	2.4	2.5
39	3.07	0.70	35.6	26.3	92.6	69.0	3.8	0.8
40	3.53	0.80	36.7	25.7	90.7	70.1	2.8	5.1
41	4.23	1.07	37.0	23.9	86.7	59.1	3.3	0.0
42	5.07	1.17	33.1	22.9	85.0	59.3	4.9	7.0
43	2.67	1.80	32.0	19.6	84.9	55.3	2.0	0.4
44	1.93	3.43	32.1	17.0	85.6	46.3	1.9	0.0
45	1.53	3.57	30.3	15.9	82.1	46.1	1.8	0.0
46	0.63	4.07	27.9	15.4	79.1	54.3	1.1	0.0
47	0.37	4.57	29.3	14.6	78.7	45.7	2.3	0.0
48	0.00	2.43	26.7	15.0	80.4	44.4	1.8	0.0
49	0.00	1.10	25.6	14.0	85.4	59.3	2.7	0.0

SMW- Standard meteorological week; W.V.- Wind velocity; Km- Kilo-meter; Hr.- Hour; mm- Milimeter.

Table 2: Correlation coefficient of pigeonpea leaf roller and leaf webber with weather parameters 2021-22.

Insects	Temperature		Relative humidity		Wind velocity	Rainfall
	Maximum	Minimum	Morning	Evening	(Km./Hr.)	(mm)
Leaf roller	0.505*	0.361^{NS}	0.288^{NS}	0.139^{NS}	0.185^{NS}	0.198^{NS}
Leaf webber	-0.463^{NS}	-0.791**	-0.857**	-0.839**	-0.723**	-0.496^{NS}

*Significant at 5% level; **Significant at 1%; NS- non-significant.

The incidence of *G. critica* was recorded (Table 4) and further analyzed with meteorological variables during consecutive year *kharif* 2022-23 and it was perceived that *G. critica* disclosed a significant positive correlation with maximum temperature (0.493). Nevertheless, significant negative correlations were observed in rainfall (-0.489). Additionally, non-significant positive correlations were found in minimum temperature (0.031), morning humidity (0.107), whereas evening humidity (-0.299) and wind velocity (-0.127) showed non-significant negative correlations. The observed correlations between the larval population of *G. critica* and the prevailing weather parameters, as documented in the current investigation, align with the findings of Bijewar *et al*. (2018), Vennila *et al*. (2019) and Seni (2021) who were confirmed that leaf webber population have positive correlation with maximum temperature whereas, it was showed negative correlation with rainfall variable. Wind speed had a negative, yet statistically non-significant, impact on the pest population, contradicting the findings of Kumar *et al.* (2010) and Dwivedi *et al.* (2013), who observed a positive influence in the preceding week. Maximum and minimum temperatures also showed a positive impact on the pest population in the present study, aligning with Kumar *et al*. (2010) findings, although statistically non-significant.

Regression equation between larval population of *Caloptilia soyella* and weather parameters during *Kharif*, 2021-22 and 2022-23

The analysed data on the regression equation reveal that the leaf roller population primarily depends on maximum temperature and minimum temperature, influencing 31.1% and 18.2%, respectively, as indicated by the coefficient of determination (r^2) during *Kharif* season 2021-22. Overall, the combined effects of all abiotic factors contribute to a 44.1% variation in the population of the leaf roller. The multiple linear regression model is fitted with as:

Y = -7.43+ 0.177*X1+0.179*X2+0.087*X3-0.114*X4-0.455*X5+ 0.213*X6.

The regression analysis during experimental period 2022-23 revealed that the leaf roller population is predominantly influenced by maximum temperature (38.8%), minimum temperature (33.6%), morning relative humidity (29.2%), evening relative humidity (16.0%) and rainfall (23.3%), as indicated by the coefficient of determination (r^2). Collectively, these abiotic factors account for 57.9% of the variation in the leaf roller population. The multiple linear regression model obtained is expressed as:

Y = -5.021+0.125*X1-0.012*X2+0.028*X3-0.018*X4+0.130*X5+0.051*X6.

Table 3: Population of leaf roller and leaf webber infesting pigeonpea 2022-23.

SMW	Mean number of larva plant^{-1}		Weather					
			Temperature		Relative humidity		W. V.	Rainfall
	Roller	Webber	Maximum	Minimum	Morning	Evening	(Km./Hr.)	(mm)
35	0.37	0.17	32.4	27.9	93.9	80.6	2.6	7.9
36	0.43	0.50	37.1	26.9	91.9	77.0	2.9	0.6
37	0.67	0.63	32.6	26.9	92.7	78.1	6.7	0.1
38	0.77	0.73	32.4	25.4	91.0	76.6	3.3	5.0
39	0.60	1.30	33.6	25.6	91.9	70.6	2.4	18.4
40	0.77	1.10	33.0	24.3	90.0	71.0	2.8	10.2
41	1.83	4.33	33.0	24.3	93.1	70.9	2.8	10.2
42	1.57	4.70	33.7	22.1	91.7	52.7	1.9	0.0
43	1.00	6.23	33.9	20.0	87.7	53.9	2.8	0.0
44	0.9	6.37	33.6	18.9	89.0	55.3	1.8	0.0
45	0.47	5.40	33.0	19.7	89.3	56.7	1.2	0.0
46	0.37	6.23	30.3	17.3	84.3	47.9	3.4	0.0
47	0.40	3.30	27.9	13.6	87.3	48.3	3.2	0.0
48	0.23	0.93	27.8	13.5	86.0	53.7	2.5	0.0
49	0.00	0.67	26.3	12.3	85.1	49.0	2.4	0.0
50	0.00	0.22	27.0	12.9	80.4	50.4	3.3	0.0

SMW- Standard meteorological week; W.V.- Wind velocity; Km- Kilo-meter; Hr.- Hour; mm- Milimeter.

Table 4: Correlation coefficient of pigeonpea leaf roller and leaf webber with weather parameters 2022-23.

Insects	Temperature		Relative humidity		Wind velocity	Rainfall
	Maximum	Minimum	Morning	Evening	(Km./Hr.)	(mm)
roller	0.626**	0.5 81*	0.541*	0.402^{NS}	0.001^{NS}	0.485*
webber	0.493*	0.031^{NS}	0.107^{NS}	-0.299^{NS}	-0.489*	-0.127^{NS}

*Significant at 5% level; **significant at 1%; NS- Non-significant.

Where:
X_1= Maximum temperature.
X_2= Minimum temperature.
X_3= Morning relative humidity.
X_4= Evening relative humidity.
X_5= Wind velocity.
X_6= Rainfall).

The existing text of research lacks extensive discussions on the effects of the leaf roller incidence in Pigeon pea. Further inquiry and academic exploration are required to understand the mechanisms driving leaf roller prevalence, analyse the related agricultural ramifications and provide significant insights to the current knowledge base in this subject.

Regression equation between larval population of *Grapholita critica* and weather parameters during *Kharif*, 2021-22 and 2022-23

The data regarding regression analysis on leaf webber population is predominantly influenced by minimum temperature (35.0%), morning relative humidity (61.4%), evening relative humidity (63.2%), wind velocity (40.4%) and rainfall (60.1%), as indicated by the coefficient of determination (r^2). In total, the combined effects of all abiotic factors contribute to an 83.78% variation in the leaf webber population. The multiple linear regression model is represented as:

$$Y = 17.432+0.003*X1+0.018*X2-0.143*X3 -0.041*X4-0.536*X5+0.107*X6.$$

It is evident from data presented (Table 4) that leaf webber population mainly depends on maximum temperature and wind velocity that influenced 24.0% and 24.1%, respectively as the value of coefficient of determination (r^2) indicated. Overall, the combined effects of all abiotic factors contribute 69.4% variation in population of leaf webber. The multiple linear regression model fitted was:

$$Y= -10.686+0.261*X_1+0.402*X_2+0.161*X_3-0.271*X_4-0.263*X_5-0.008*X_6.$$

Seni (2021) concluded that leaf webber population was highly influenced by relative humidity variable and contribute 9.10% variation in population, which are similar to more or less present findings.

CONCLUSION

In *Kharif* 2021-22, leaf roller incidence on pigeon pea increased steadily, peaking at 5.07 larvae in the 42nd week. In *Kharif* 2022-23, it reached 1.83 larvae in the 41st week. *Grapholita critica* on pigeon pea peaked at 4.57 larvae plant^{-1} (*Kharif* 2021-22) and 6.37 larvae plant^{-1} (Kharif 2022-23) in the 47th and 44th weeks, respectively. Correlation analyses revealed significant positive associations between leaf roller incidence and maximum temperature (*Kharif* 2021-22: 0.505, *Kharif* 2022-23: 0.626), minimum temperature (*Kharif* 2022-23: 0.581), morning humidity (Kharif 2022-23: 0.541) and rainfall (*Kharif* 2022-23: 0.485). Evening humidity and wind velocity were not significantly correlated in either season. Leaf webber in *Kharif* 2021-22 exhibited highly substantial negative correlations with minimum temperature (-0.791), morning humidity (-0.857), evening humidity (-0.839), wind velocity (-0.723) and rainfall (-0.496). *G. critica* in *Kharif* 2022-23 showed a significant positive correlation with maximum temperature (0.493) and a significant negative correlation with rainfall (-0.489). Minimum temperature (0.031), morning humidity (0.107), evening humidity (-0.299) and wind velocity (-0.127) had non-significant correlations. Maximum temperature was the most influential factor for leaf roller populations (38.8%). Combined with other abiotic factors, it explained 57.9% of the variation. For leaf Webber, minimum temperature, humidity, wind and rainfall collectively contributed to 83.78% variation. Maximum temperature and wind velocity were pivotal, explaining 69.4% of the population variation. In conclusion, the study provides comprehensive insights into the intricate relationships between climatic variables and pest populations in pigeon pea cultivation. These findings contribute to the understanding of pest dynamics and inform targeted pest management strategies for sustainable agriculture.

Conflict of interest

The authors confirm that they have no conflicts of interest and agree with the manuscript's content. They declare no financial interests and certify that the submission is original and not under review by any other publication.

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