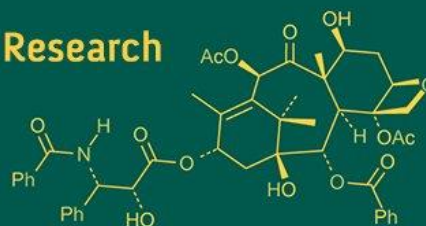


International Journal of Advanced Biochemistry Research



ISSN Print: 2617-4693
ISSN Online: 2617-4707
NAAS Rating (2026): 5.29
IJABR 2026; 10(8): 633-638
www.biochemjournal.com
Received: 12-05-2026
Accepted: 19-07-2026

Pooja Sinha
Guest Teacher, Department of
Entomology, CHRS, Raigarh,
MGUVV, Sankara- Patan Durg,
Chhattisgarh, India

Rajkumar Rathore
Ph.D. Scholar, Department of
Entomology, Rajmata
Vijayaraje Scindia Krishi
Vishwavidyalaya, Gwalior,
Madhya Pradesh, India

Kunjum Pradeep rao Likhitar
Ph.D. Scholar, Department of
Entomology, Rajmata
Vijayaraje Scindia Krishi
Vishwavidyalaya Gwalior,
Madhya Pradesh, India

Rajesh Kumar Joshi
M.Sc. (Ag.) Scholar, Dept. of
Horticulture, Ghanshyam
Urvashi Mahavidyalaya Phulpur
Prayagraj, Prof. Rajendra Singh
(Rajju Bhaiya) University,
Prayagraj, Uttar Pradesh, India

Prashant Kumar Yadav
M.Sc. (Ag.) Entomology, Dept of
Entomology, Rajmata
Vijayaraje Scindia Krishi
Vishwavidyalaya Gwalior,
Madhya Pradesh, India

Kurru Charitha
Ph.D. Scholar, Department of
Entomology, Rajmata
Vijayaraje Scindia Krishi Vishwa
Vidyalaya, Gwalior, Madhya
Pradesh, India

Maneesha
Ph.D. Scholar, Department of
Entomology, Rajmata
Vijayaraje Scindia Krishi Vishwa
Vidyalaya, Gwalior, Madhya
Pradesh, India

Corresponding Author:
Pooja Sinha
Guest Teacher, Department of
Entomology, CHRS, Raigarh,
MGUVV, Sankara- Patan Durg,
Chhattisgarh, India

Effect of maize–legume intercropping on fall armyworm *Spodoptera frugiperda* (J. E. Smith) incidence

Pooja Sinha, Rajkumar Rathore, Kunjum Pradeep Rao Likhitar, Rajesh Kumar Joshi, Prashant Kumar Yadav, Kurru Charitha and Maneesha

DOI: <https://www.doi.org/10.33545/26174693.2026.v10.i8h.9684>

Abstract

A field investigation was undertaken during kharif 2022 at the Research-cum-Instructional Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur (Chhattisgarh), to assess the influence of maize–legume intercropping systems on the incidence of fall armyworm (FAW), *Spodoptera frugiperda*, and to relate larval build-up with key morphological traits of maize. Seven treatments comprising maize intercropped with green gram, black gram and cowpea in 1:1 and 2:2 row ratios, along with a sole-maize control, were evaluated in a randomized block design with three replications. The lowest larval population (0.90 larvae per five plants) and the least leaf damage (28.0%) were recorded under the Maize + Cowpea (1:1) system, followed by Maize + Cowpea (2:2) and Maize + Green gram (1:1), while sole maize sustained the highest larval load (3.86 larvae per five plants) and leaf damage (42.06%). Plant height, number of leaves per plant and leaf area index were all significantly and negatively correlated with larval population ($r = -0.903$, -0.891 and -0.913 , respectively), indicating that intercropping-induced improvement in maize vigour is associated with reduced FAW pressure. The Maize + Cowpea (1:1) system also produced the highest maize grain equivalent yield (54.30 q ha^{-1}), followed by Maize + Cowpea (2:2) (52.36 q ha^{-1}) and Maize + Green gram (2:2) (49.56 q ha^{-1}). These findings support maize–cowpea intercropping in a 1:1 ratio as an economically and ecologically sound component of an integrated management strategy against fall armyworm.

Keywords: Fall armyworm, *Spodoptera frugiperda*, maize–legume intercropping, correlation, morphological traits, grain equivalent yield

1. Introduction

Maize (*Zea mays* L.) is one of the most versatile cereal crops cultivated across diverse agro-ecologies and is a major source of food, feed and industrial raw material worldwide. Its productivity, however, is persistently threatened by insect pests, among which the fall armyworm, *Spodoptera frugiperda* (J. E. Smith) (*Lepidoptera: Noctuidae*), has emerged as one of the most destructive invasive pests since its detection on the Indian subcontinent. The polyphagous and highly mobile nature of this pest, combined with its preference for the whorl stage of maize, allows it to cause extensive defoliation, whorl damage and yield loss if left unmanaged. Reliance on synthetic insecticides for fall armyworm management raises concerns of residue build-up, resurgence, development of resistance and adverse effects on natural enemies and the environment. Consequently, ecologically compatible tactics that lower pest pressure without relying solely on chemical inputs have gained importance within integrated pest management programmes. Cereal–legume intercropping is one such cultural practice: legumes intercropped with maize can modify the microclimate, alter host-plant apparency and volatile cues used by ovipositing moths, support natural enemies, and improve soil fertility and crop vigour, all of which may contribute to reduced pest colonisation and damage.

Beyond its direct pest-suppressive role, intercropping is known to influence the morphological development of the companion cereal crop, and traits such as plant height, foliage density and leaf area index have frequently been linked with the extent of insect infestation, since a more vigorous canopy can both dilute apparency to pests and tolerate a given level of feeding better than a sparse one. However, quantitative evidence linking fall armyworm incidence with specific morphological attributes of maize under different legume intercropping geometries remains limited, particularly under the agro-climatic conditions of central India.

Keeping this background in view, the present study was carried out with the objectives of (i) evaluating the effect of maize intercropped with green gram, black gram and cowpea in 1:1 and 2:2 row proportions on the incidence of fall armyworm, (ii) examining the correlation between larval population and plant height, number of leaves and leaf area index of maize, and (iii) assessing the consequent effect of these intercropping systems on maize grain equivalent yield.

2. Materials and Methods

2.1 Experimental site and season

The field experiment was conducted during the kharif season of 2022 at the Research-cum-Instructional Farm of Indira Gandhi Krishi Vishwavidyalaya (IGKV), Raipur, Chhattisgarh, India, under natural, unprotected field conditions that permitted uniform and adequate fall armyworm pressure across treatments.

2.2 Experimental details

Table 1: Experimental details of the field trial

Particular	Detail
Season	Kharif 2022
Maize variety	DKC-9141
Experimental design	Randomized Block Design (RBD)
Number of replications	Three
Number of treatments	Seven
Spacing (row × plant)	75 cm × 20 cm
Date of sowing	05 August 2022
Gross plot size	4 m × 7.20 m
Distance between replications	1 m
Distance between plots	0.5 m

2.3 Treatment details

Seven treatments, involving maize intercropped with three legumes at two row proportions and an unintercropped control, were laid out as follows:

Table 2: Treatment details of the maize–legume intercropping systems evaluated

Treatment	Intercropping system	Row ratio (maize:legume)
T ₁	Maize + Green gram	1:1
T ₂	Maize + Black gram	1:1
T ₃	Maize + Cowpea	1:1
T ₄	Maize + Green gram	2:2
T ₅	Maize + Black gram	2:2
T ₆	Maize + Cowpea	2:2
T ₇	Sole maize (control)	—

2.4 Observations recorded

Fall armyworm larval counts and morphological observations were recorded at 10-day intervals through the crop growth cycle, with five randomly selected and tagged plants per plot used for all observations, in order to relate pest incidence with the growth pattern of the crop.

2.4.1 Larval population

The number of fall armyworm larvae present in the whorls and on the foliage of five randomly tagged plants per plot was counted and expressed as the mean number of larvae per five plants.

2.4.2 Plant height (cm)

Plant height of the five tagged plants in each plot was measured 45 days after sowing (DAS), from the ground

level to the tip of the fully unfurled leaf prior to tasselling, or to the tip of the tassel thereafter, using a meter scale. The mean of five plants was recorded as the plant height for that plot.

2.4.3 Number of leaves per plant

The fully expanded, green leaves on each of the five tagged plants were counted at 45 DAS and averaged to obtain the mean number of leaves per plant.

2.4.4 Leaf area index (LAI)

Leaf area index, defined as the ratio of total green leaf area to the ground area occupied by the plant (Watson, 1947) ^[2], was computed from the length and width of individual leaves on the five tagged plants and averaged across plants and replications

2.4.5 Leaf damage and grain equivalent yield

Per cent leaf damage caused by fall armyworm feeding was recorded on the tagged plants, and maize grain yield from each intercropping system was converted to a maize grain equivalent yield ($q\ ha^{-1}$) to allow comparison of system productivity on a common basis.

2.5 Statistical analysis

Data were subjected to analysis of variance as appropriate for a randomized block design, and standard error of mean (SEm±) and critical difference (CD at 5% probability) were computed following Gomez and Gomez (1984) ^[1]. Simple Pearson correlation coefficients were worked out between larval population and each morphological trait, and simple linear regression equations were fitted to describe the relationship of larval incidence with plant height, number of leaves and leaf area index.

3. Results and Discussion

3.1 Effect of intercropping systems on fall armyworm larval population

The mean number of fall armyworm larvae recorded per five plants differed significantly among the seven treatments (Table 3, Fig. 1). The lowest larval population, 0.90 larvae per five plants, was recorded in the Maize + Cowpea (1:1) system, statistically superior to all other treatments. This was followed by Maize + Green gram (1:1) with 1.43 larvae, and Maize + Green gram (2:2) with 1.80 larvae per five plants. The Maize + Cowpea (2:2) system supported 2.13 larvae, while Maize + Black gram (1:1) and Maize + Black gram (2:2) recorded 2.16 and 2.76 larvae per five plants, respectively. The unintercropped sole maize control carried the heaviest larval load, 3.86 larvae per five plants, roughly four times that of the best-performing Maize + Cowpea (1:1) treatment.

Table 3: Effect of different intercropping systems on fall armyworm larval population

S. No.	Treatment	Larval population (no. per five plants)
1	Maize + Green gram (1:1)	1.43
2	Maize + Black gram (1:1)	2.16
3	Maize + Cowpea (1:1)	0.90
4	Maize + Green gram (2:2)	1.80
5	Maize + Black gram (2:2)	2.76
6	Maize + Cowpea (2:2)	2.13
7	Sole maize (Control)	3.86
	SEm±	0.11
	CD @ 5%	0.88

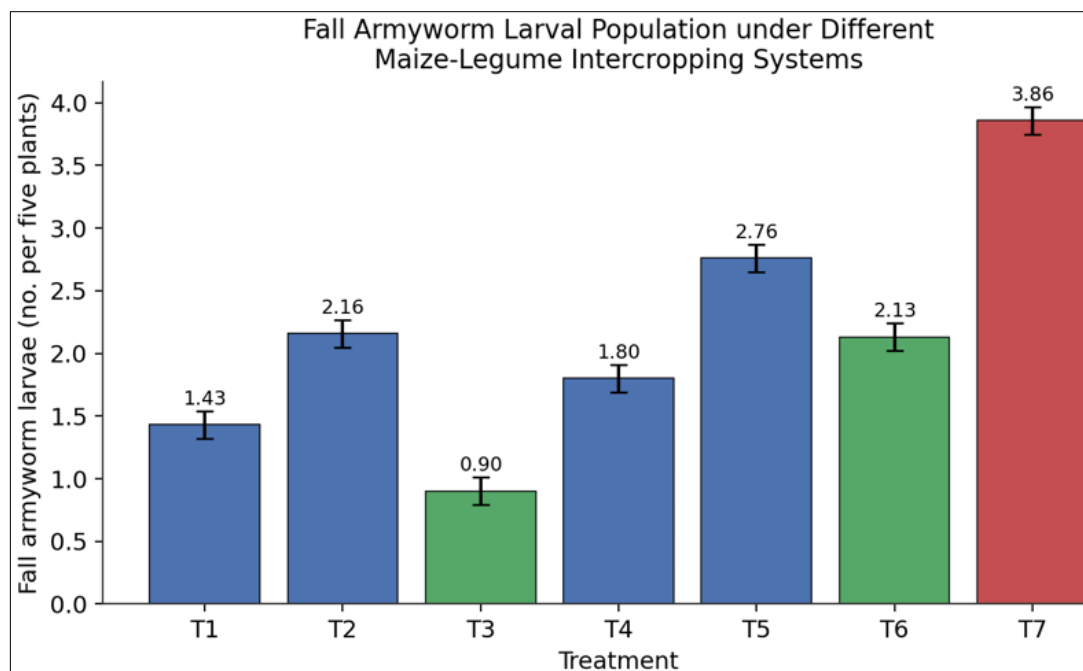


Fig 1: Fall armyworm larval population under different maize–legume intercropping systems (error bars = SEM±).

The consistently lower larval incidence under legume intercropping, and particularly under maize–cowpea combinations, is in line with the general premise that companion legumes disrupt the visual and olfactory host-finding cues used by oviposition fall armyworm moths, while also creating a more favourable microhabitat for natural enemies. The superiority of the 1:1 ratio over the 2:2 ratio across all three legumes suggests that a higher relative proportion and more even spatial distribution of the legume component strengthens this disruptive effect compared with wider blocks of maize rows in the 2:2 arrangement.

3.2 Effect of intercropping on morphological traits of maize and their correlation with larval population

Growth parameters recorded at 45 DAS, namely plant height, number of leaves per plant and leaf area index, varied among the intercropping systems and showed a consistent inverse relationship with fall armyworm larval population (Table 4, Fig. 2, Fig. 3).

Table 4: Morphological characters of maize and associated fall armyworm larval population under different intercropping systems (45 DAS).

Treatment	Larvae (no./5 plants)	Plant height (cm)	Leaves/plant (no.)	Leaf area index
T ₁	1.43	84.80	6.16	1.56
T ₂	2.16	83.60	5.83	1.40
T ₃	0.90	86.90	6.43	1.76
T ₄	1.80	84.60	5.80	1.53
T ₅	2.76	82.36	5.60	1.26
T ₆	2.13	86.30	6.36	1.70
Control	3.86	79.80	5.03	1.03
SEm±	0.11	0.28	0.11	0.04
CD @ 5%	0.88	0.88	0.35	0.15

3.2.1 Plant height

Plant height at 45 DAS ranged from 79.80 cm in the sole maize control to a maximum of 86.90 cm in Maize +

Cowpea (1:1). A significant negative correlation was observed between plant height and larval population ($r = -0.903$), and the fitted regression, $Y = -0.36X + 32.36$ (where Y is larval population and X is plant height in cm), indicated that each additional centimetre of plant height was associated with a decline in larval numbers, consistent with taller, more vigorously growing plants being less attractive or less suitable for larval establishment and survival.

3.2.2 Number of leaves per plant

The number of leaves per plant was highest in Maize + Cowpea (1:1) (6.43 leaves) and lowest in sole maize (5.03 leaves).

Leaf number showed a significant negative correlation with larval population ($r = -0.891$), with the regression $Y = -1.76X + 12.49$ indicating a comparable decline in larval numbers with greater foliage density, likely reflecting both a dilution effect on oviposition moths and improved plant tolerance to feeding damage.

3.2.3 Leaf area index

Leaf area index followed the same pattern, ranging from 1.03 in sole maize to 1.76 in Maize + Cowpea (1:1), and was significantly and negatively correlated with larval population ($r = -0.913$; $Y = -3.41X + 7.14$), the strongest of the three associations recorded in this study. This suggests that overall canopy development, integrating both plant height and leafiness, was the trait most closely linked with reduced fall armyworm incidence among the intercropping systems tested.

Taken together, the strongly negative correlations for all three traits (Table 4, Fig. 2) point to a consistent pattern in which intercropping systems that promoted better maize growth also experienced lower fall armyworm pressure, whether through improved plant vigour and tolerance, or through the concurrent microclimatic and cue-masking effects of the legume component itself.

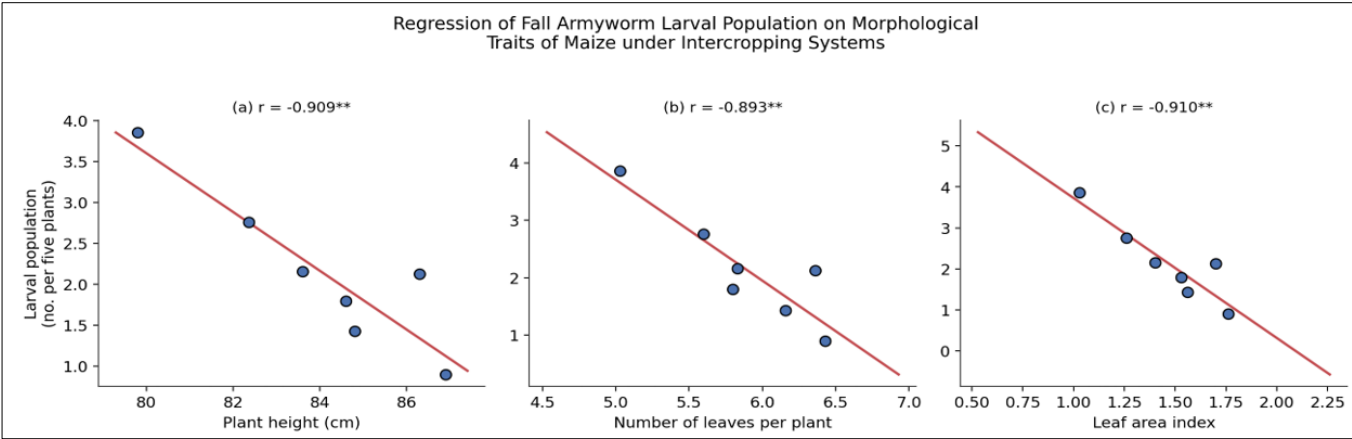


Fig 2: Regression of fall armyworm larval population on (a) plant height, (b) number of leaves per plant, and (c) leaf area index of maize. ****** significant at $p < 0.01$.

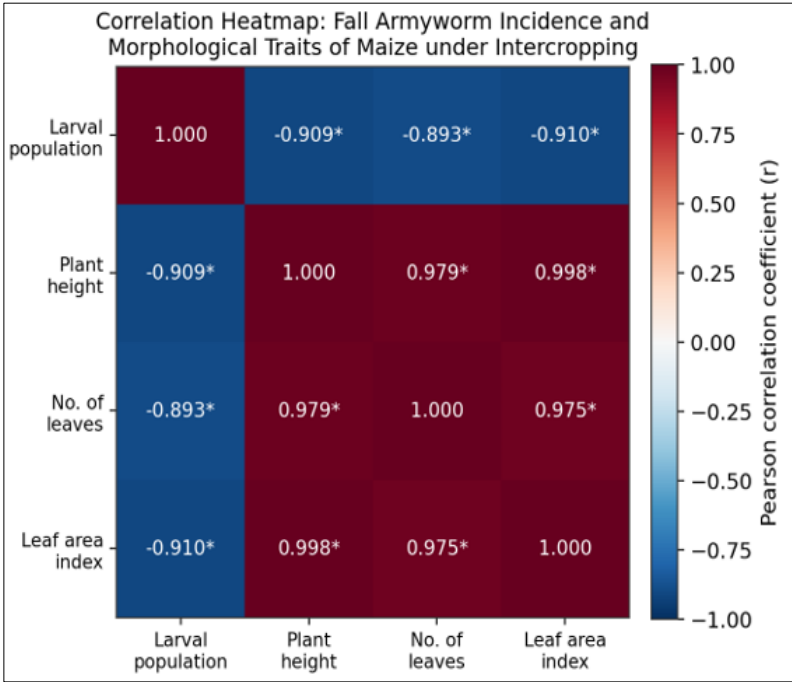


Fig 3: Correlation heatmap between fall armyworm larval population and morphological traits of maize (Pearson r). * indicates a strong correlation ($|r| \geq 0.62$).

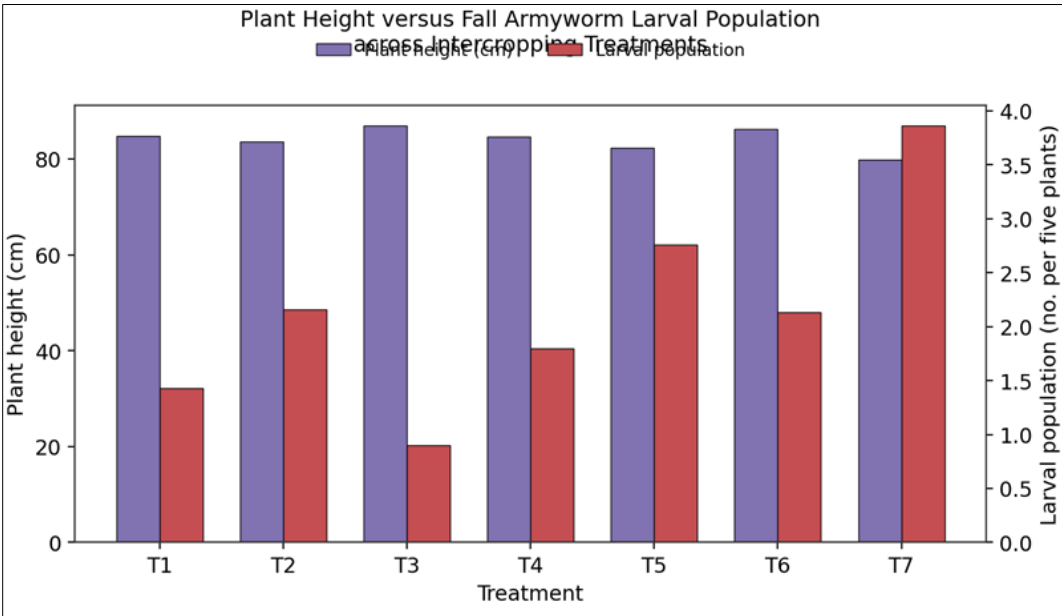


Fig 4: Comparative trend of maize plant height and fall armyworm larval population across intercropping treatments.

3.3 Leaf damage

Per cent leaf damage mirrored the trend observed for larval population (Table 5, Fig. 4). The least leaf damage was recorded under Maize + Cowpea (1:1) (28.0%), followed closely by Maize + Cowpea (2:2) (28.30%), and by Maize + Green gram (30.80%) and Maize + Black gram (32.00%) systems, whereas sole maize suffered the greatest damage (42.06%), around 1.3 to 1.5 times higher than the intercropped treatments.

Table 5: Per cent leaf damage caused by fall armyworm under different maize–legume intercropping systems.

Intercropping system	Leaf damage (%)
Maize + Cowpea (1:1)	28.00
Maize + Cowpea (2:2)	28.30
Maize + Green gram (mean of ratios)	30.80
Maize + Black gram (mean of ratios)	32.00
Sole Maize (Control)	42.06

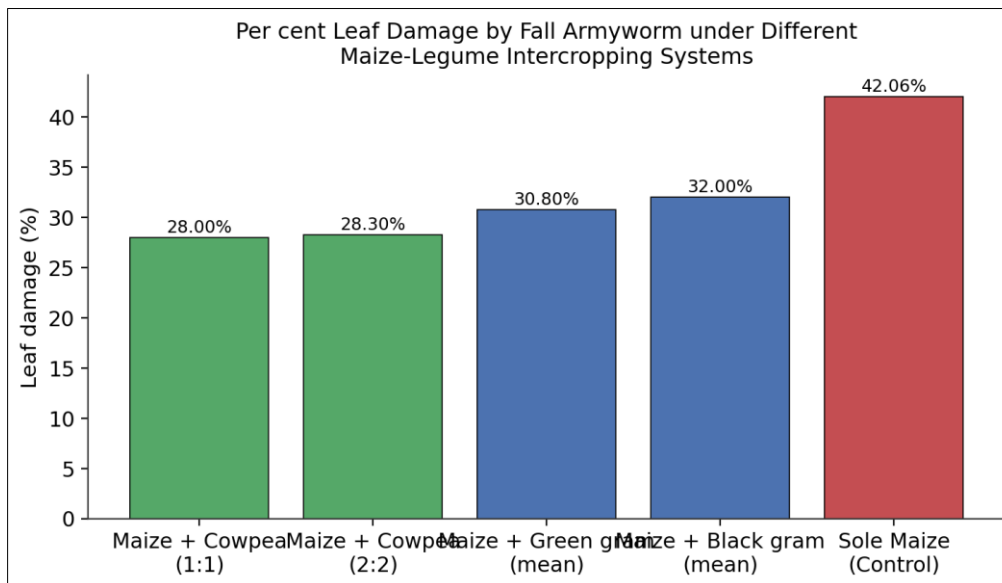


Fig 5: Per cent leaf damage by fall armyworm under different maize–legume intercropping systems.

3.4 Maize grain equivalent yield

The reduction in fall armyworm pressure and leaf damage under legume intercropping translated into higher productivity.

Maize + Cowpea (1:1) produced the highest maize grain

equivalent yield (54.30 q ha⁻¹), followed by Maize + Cowpea (2:2) (52.36 q ha⁻¹) and Maize + Green gram (2:2) (49.56 q ha⁻¹) (Table 6, Fig. 6), reflecting the combined benefit of reduced pest damage and the additional productivity contributed by the legume component itself.

Table 6: Maize grain equivalent yield under selected maize–legume intercropping systems.

Intercropping system	Maize grain equivalent yield (q/ha)
Maize + Cowpea (1:1)	54.30
Maize + Cowpea (2:2)	52.36
Maize + Green gram (2:2)	49.56

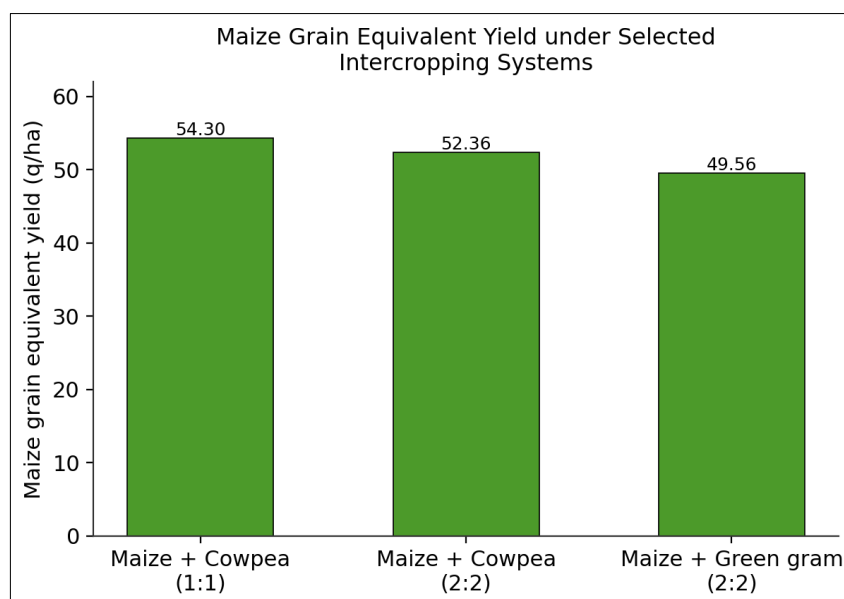


Fig 6: Maize grain equivalent yield under selected intercropping systems.

3.5 Correlation summary

A consolidated correlation matrix among larval population and the three morphological traits (Table 7, Fig. 2) confirms strong, significant negative associations between larval incidence and plant height, leaf number and leaf area index, and correspondingly strong positive associations among the three morphological traits themselves, indicating that they change together as an integrated expression of crop vigour under the different intercropping environments.

Table 7: Pearson correlation matrix between fall armyworm larval population and morphological traits of maize (** significant at $p < 0.01$).

Variable	Larval population	Plant height	Leaves/plant	Leaf area index
Larval population	1.000	-0.903**	-0.891**	-0.913**
Plant height	-0.903**	1.000	0.979**	0.998**
Leaves/plant	-0.891**	0.979**	1.000	0.975**
Leaf area index	-0.913**	0.998**	0.975**	1.000

4. Conclusion

Maize–legume intercropping, particularly Maize + Cowpea in a 1:1 row ratio, was consistently associated with the lowest fall armyworm larval population, the least leaf damage and the highest maize grain equivalent yield among the systems evaluated, whereas sole maize was the most vulnerable and least productive. Plant height, number of leaves per plant and leaf area index were all strongly and negatively correlated with larval incidence, indicating that intercropping-driven improvement in maize canopy development is closely linked with reduced fall armyworm pressure. On the basis of these results, maize–cowpea intercropping at a 1:1 ratio can be recommended as an economically viable and ecologically compatible component of integrated fall armyworm management, meriting further validation across seasons and locations.

5. Acknowledgment

The author expresses gratitude to the Department of Entomology, Indira Gandhi Krishi Vishwavidyalaya, Raipur for their valuable suggestions, unending assistance and moral support while on the course of the investigation

References

1. Gomez KA, Gomez AA. Statistical procedures for agricultural research. 2nd ed. New York: John Wiley & Sons. 1984.
2. Watson DJ. Comparative physiological studies on the growth of field crops: I. Variation in net assimilation rate and leaf area between species and varieties, and within and between years. *Annals of Botany*. 1947;11(41):41-76.
3. Sharanabasappa, Kalleshwaraswamy CM, Asokan R, Swamy HM, Maruthi MS, Pavithra HB, *et al.* First report of the fall armyworm, *Spodoptera frugiperda* (J. E. Smith) (*Lepidoptera: Noctuidae*), an alien invasive pest on maize in India. *Pest Management in Horticultural Ecosystems*. 2018;24(1):23-29.
4. Prasanna BM, Huesing JE, Eddy R, Peschke VM, editors. Fall armyworm in Africa: a guide for integrated pest management. Mexico City: CIMMYT. 2018.

5. Altieri MA. The ecological role of biodiversity in agroecosystems. *Agriculture, Ecosystems & Environment*. 1999;74(1-3):19-31.
6. Andow DA. Vegetational diversity and arthropod population response. *Annual Review of Entomology*. 1991;36(1):561-586.