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Antixenosis and antibiosis mechanisms of resistance in chickpea germplasm against gram pod borer, *Helicoverpa armigera* (Hübner)

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ABSTRACT

Chickpea (*Cicer arietinum* L.) is the most important rabi pulse crop of India, valued for its high protein content, wide adaptability and nitrogen-fixing ability, but its productivity is severely constrained by the gram pod borer, *Helicoverpa armigera* (Hübner), a highly polyphagous and destructive pest capable of causing yield losses of 20 to 95 per cent. Host plant resistance constitutes an economical and environmentally sound component of integrated pest management, and identification of the morphological (antixenosis) and biochemical (antibiosis) bases of resistance is essential for breeding resistant cultivars. A field-cum-laboratory investigation was carried out at the Department of Entomology, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, during rabi 2025-26 to evaluate antixenosis and antibiosis resistance among 37 chickpea germplasms against *H. armigera*. For antixenosis, plant type, trichome type, glandular and non-glandular trichome length and density on leaves and pods, pod length, pod width, pod wall thickness and seed arrangement were recorded and correlated with larval population. Erect genotypes generally recorded lower infestation than spreading types. Glandular and non-glandular trichome lengths on leaves and pods (0.08-0.29 mm) were significantly and negatively correlated with larval population ($r = -0.354^*$ to -0.541^{**}), while leaf and pod trichome densities (10.50-25.50 and 13.50-28.50 trichomes/mm², respectively) showed highly significant negative correlations ($r = -0.550^{**}$ and -0.577^{**}). Pod wall thickness (0.14-0.29 mm) was also negatively correlated with larval population ($r = -0.411^*$), whereas pod length and pod width showed non-significant associations. Fifteen germplasms representing contrasting field reactions were further evaluated for antibiosis through estimation of total phenol, total soluble sugar, flavonoid, malic acid and tannin content. Total phenol (0.20-0.33 mg/g) recorded the strongest negative correlation with larval population ($r = -0.792^{**}$), followed by flavonoid ($r = -0.697^{**}$, 0.07-0.17 mg/g), tannin ($r = -0.572^*$, 0.62-1.50 mg/g) and malic acid ($r = -0.544^*$, 0.70-1.48%), whereas total soluble sugar (3.70-7.25 °Brix) was positively correlated with larval population ($r = 0.664^{**}$). Germplasms L550, GJG 2306, IPC 2020-123 and BG 4078 combined favourable trichome, pod wall and biochemical profiles and are recommended as promising donor sources of antixenosis and antibiosis resistance for utilisation in chickpea resistance-breeding programmes against *H. armigera*.

Keywords: Chickpea, *Helicoverpa armigera*, Antixenosis, Antibiosis, Trichome, Biochemical resistance, Host plant resistance

1. Introduction

Chickpea (*Cicer arietinum* L.), commonly known as Bengal gram, is the most important pulse crop grown during the *rabi* season in India, contributing nearly 45 per cent of the country's total pulse production and serving as a major source of dietary protein (20-22%), carbohydrates and essential minerals, particularly for the vegetarian population (Jukanti *et al.*, 2012; Merga *et al.*, 2019) [1, 2]. Globally, chickpea is cultivated on about 14.5 million hectares with an annual production of approximately 16.0 million tonnes, while India alone accounts for about 10.1 million hectares and 11.6 million tonnes of production (FAO, 2024; NITI Aayog, 2025) [3, 4]. In Chhattisgarh, chickpea is predominantly grown after rice under residual soil moisture over 0.15-0.20 million hectares, with the crop concentrated in the districts of Bemetara, Kabirdham, Rajnandgaon, Durg and Balod (Directorate of Agriculture *et al.*, 2025; Directorate of Economics and Statistics, 2025) [5, 6].

Chickpea productivity is severely constrained by insect pests, of which the gram pod borer, *Helicoverpa armigera* (Hübner) (Lepidoptera: Noctuidae), is the most destructive and economically important field pest across major chickpea-growing regions of the world (Sharma *et al.*, 2007) [7]. This highly polyphagous, multivoltine and cosmopolitan insect feeds on more than 180 plant species and its larvae bore into pods and consume developing seeds, causing yield losses ranging from 20 to 95 per cent depending on germplasm, crop

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stage and pest pressure (Pawar, 1998; Sharma, 2005; Randhawa *et al.*, 2025) [8, 9, 10]. Excessive and repeated use of chemical insecticides against *H. armigera* has led to resurgence of the pest, insecticide resistance and adverse effects on natural enemies and the environment. Under such circumstances, host plant resistance (HPR) is considered one of the most economical, durable and environmentally compatible components of integrated pest management. Resistance may operate through antixenosis (non-preference), antibiosis or tolerance mechanisms (Painter, 1951) [11]. Morphological and physio-morphological traits such as plant growth habit, trichome type, trichome length and density, pod wall thickness and pod size are important components of antixenosis, reducing insect preference, oviposition and larval establishment (Shabbir *et al.*, 2014; Hossain *et al.*, 2008) [13, 12]. In addition, biochemical constituents such as phenols, flavonoids, tannins, sugars and organic acids influence larval feeding, growth and survival, thereby contributing to antibiosis resistance (Sharma *et al.*, 2005; Golla *et al.*, 2020; Sane *et al.*, 2025) [15, 14, 16]. Germplasm possessing favourable morphological and biochemical characteristics generally exhibits lower larval establishment and reduced pod damage, and the identification and utilisation of such resistant germplasm can reduce dependence on chemical insecticides while conserving natural enemies (Rehman *et al.*, 2024; Sharma *et al.*, 2020) [17, 18]. Although extensive work has been carried out on individual morphological or biochemical traits associated with resistance in chickpea, an integrated field-cum-laboratory assessment of both antixenosis and antibiosis mechanisms within the same set of germplasm under the agro-climatic conditions of Chhattisgarh has received comparatively limited attention. Keeping this in view, the present investigation was undertaken to evaluate (i) the antixenosis resistance of chickpea germplasm based on morphological and physio-morphological traits, and (ii) the antibiosis resistance based on biochemical constituents, against gram pod borer, *H. armigera*, with the objective of identifying promising donor sources for utilisation in resistance-breeding programmes.

2.4 Evaluation of antibiosis resistance

On the basis of field reaction and the Pest Resistance Susceptibility Rating (PRSR) scale (Reed *et al.*, 1980) [21], fifteen chickpea germplasms representing contrasting levels of resistance and susceptibility were selected from the 37 germplasms for biochemical analysis. Total phenol content was estimated by the Folin-Ciocalteu method (Malick *et al.*, 1980) [22], with absorbance recorded at 650 nm against a catechol standard. Total soluble sugar content was measured using a hand refractometer and expressed in °Brix (Srivastava *et al.*, 1994) [23]. Total flavonoid content was estimated by the aluminium chloride colorimetric method using quercetin as the reference standard, with absorbance recorded at 510 nm (Zhishen *et al.*, 1999) [24]. Malic acid content was determined by titrating leaf washings against 0.01 N NaOH using phenolphthalein as indicator (Rembold, 1981) [25]. Tannin content was estimated by the vanillin-hydrochloride method using catechin as the standard, with absorbance measured at 500 nm (Burns, 1971) [26].

2.5 Statistical analysis

The larval population data were subjected to square-root transformation ($\sqrt{x} + 0.5$) and the pod damage percentage data were arcsine-transformed prior to analysis of variance under the Randomized

2. Materials and methods

2.1 Experimental site

Field experiments were conducted at the Research-cum-Instructional Farm, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya (IGKV), Raipur, Chhattisgarh, during *rabi* 2025-26, while biochemical analyses were carried out in the laboratory of the Department of Entomology. Raipur is located in the mid-eastern part of Chhattisgarh at 21°16'N latitude, 81°36'E longitude and at an elevation of 289.56 m above mean sea level.

2.2 Experimental material

A total of 37 chickpea germplasms, including the resistant check L550 and the susceptible check JG315, were selected based on their agronomic importance, availability and expected variability in reaction to *H. armigera* (Table 1). The crop was raised in a Randomized Block Design with two replications, in single rows of 3 m length with 3 m × 3 m plot size and 30 cm × 10 cm spacing. The crop was sown on 3 December 2025 and harvested on 18 March 2026, following the recommended package of practices for chickpea cultivation.

2.3 Evaluation of antixenosis resistance

Plant type was recorded visually and genotypes were classified as erect, semi-erect or spreading based on growth habit and branching pattern (Rahman *et al.*, 2000) [19]. Trichome type (glandular and non-glandular) was determined by preparing epidermal mounts of leaf and pod samples and examining them under a compound microscope (Shabbir *et al.*, 2014) [13]. For trichome length and density, uniformly developed leaf and pod samples were cleared in acetic acid-alcohol (2:1) and mounted in 90% lactic acid, and trichomes were measured and counted under a stereo microscope at 40× magnification, density being expressed as number of trichomes mm⁻². Pod wall thickness was measured using a digital Vernier caliper on hand-cut cross-sections at four points on five pods per entry (Hossain *et al.*, 2008) [12], and pod length and pod width were similarly measured on representative pods. Arrangement of seeds within the pod was recorded visually on mature pods (Van der Maesen, 1987) [20]. Larval population of *H. armigera* was recorded on ten randomly selected plants per germplasm per replication at the vegetative, 50% flowering and 50% pod maturity stages, and per cent pod damage was worked out at harvest as:

$$\text{Pod damage (\%)} = \frac{\text{Number of damaged pods}}{\text{Total number of pods}} \times 100$$

Block Design (Gomez *et al.*, 1984) [27]. Simple correlation coefficients (*r*) were worked out between larval population and each of the antixenosis and antibiosis characters, and their significance was tested by the *t*-test at *n*-2 degrees of freedom. Standard error, critical difference (5%) and coefficient of variation were computed following standard statistical procedures.

RC- Resistant check, SC- susceptible check

3. Results and discussion

3.1 Antixenosis resistance in chickpea germplasm

3.1.1 Plant type

The 37 chickpea germplasms exhibited variation in growth habit and were classified into erect, semi-erect and spreading types based on plant architecture. Erect genotypes generally recorded lower larval infestation and pod damage than spreading types, probably due to differences in canopy structure that influence oviposition sites and larval movement. These findings agree with Yadav *et al.* (2006) [28] and Sharma *et al.* (2018) [29], who reported that spreading chickpea genotypes suffered greater *H. armigera* infestation than erect, compact types, and with Sane *et al.* (2025) [16], who identified erect plant type and compact canopy among the morphological traits associated with reduced oviposition and larval establishment.

Table 1. List of chickpea germplasms screened for their reaction to *Helicoverpa armigera*

S.No.	Germplasm	S.No.	Germplasm
1	BDNG 220-61	20	Phule G-1705-2-9
2	IPCB 2019-93	21	GNG-2701
3	NBEG 1740	22	AKG-2240
4	BG 4075	23	IPC 2021-134
5	Phule G 1620-7-3	24	NBEG 1469
6	GLD 21009	25	COC 1902
7	KCD 25047	26	GJG 2401
8	GDG 2314	27	RVSS G-154
9	RVSS G 139	28	BRC 2024-16
10	JG 2024-87	29	VCMH-24-5
11	H 21-03	30	RKG 25-10
12	RVSS G 140	31	JG 2025-101
13	Phule G-1705-8-20	32	RKGM 20-1
14	PG 425	33	Sper annegiri
15	IPC 2020-123	34	JGK 5
16	Keonjhar chana 2	35	Phule G-0517
17	GJG 2210	36	L550 (RC)
18	GJG 2306	37	JG315 (SC)
19	BG 4078		

3.1.2 Trichome length on leaf and pod

Glandular trichome length on leaves ranged from 0.10 to 0.29 mm, with the highest recorded in Phule G-1705-2-9 (0.29 mm) and the lowest in GNG-2701, COC 1902 and JG315 (0.10 mm); this trait showed a significant negative correlation with larval population ($r = -0.357^*$). Non-glandular trichome length on leaves ranged from 0.08 to 0.28 mm, being highest in GJG 2306 and L550 (0.28 mm) and lowest in RVSS G 139 (0.08 mm), with a highly significant negative correlation ($r = -0.541^{**}$). On pods, glandular trichome length ranged from 0.10 to 0.27 mm ($r = -0.371^*$) and non-glandular trichome length ranged from 0.17 to 0.28 mm ($r = -0.354^*$), both being negatively associated with larval population (Table 2, Table 3).

These results are in agreement with Shabbir *et al.* (2014) [13] and Hossain *et al.* (2008) [12], who reported that chickpea germplasms possessing longer trichomes recorded comparatively lower pod damage. Longer trichomes may act as a physical barrier that restricts larval movement and feeding, while glandular trichomes may additionally release secondary metabolites or sticky exudates that reduce host acceptance, together contributing to antixenosis resistance.

3.1.3 Trichome density on leaf and pod

Leaf trichome density ranged from 10.50 to 25.50 trichomes mm^{-2} , with the highest in GJG 2306 (25.50) and the lowest in RVSS G 139 (10.50), and showed a highly significant negative correlation with larval population ($r = -0.550^{**}$). Pod trichome density ranged from 13.50 to 28.50 trichomes mm^{-2} , with the highest in L550 (28.50) and the lowest in NBEG 1740 and Phule G-0517 (13.50), and was also highly significantly negatively correlated with larval population ($r = -0.577^{**}$). Both glandular and non-glandular trichomes were observed on the leaf and pod surfaces of all germplasms, with non-glandular trichomes generally more prominent.

These findings are consistent with Johnpeter *et al.* (1995) [30], Kanchana *et al.* (2005) [31] and Noreen *et al.* (2024) [32], who all reported that greater trichome density was associated with lower pod damage in chickpea. Higher trichome density may function as an effective physical barrier that interferes with larval movement, feeding and oviposition, thereby making the plant less suitable for *H. armigera*.

3.1.4 Pod length, pod width and pod wall thickness

Mean pod length varied from 9.30 to 18.85 mm and mean pod width from 6.35 to 10.60 mm among the germplasms, but neither trait showed a significant association with larval population ($r = -0.238^{\text{NS}}$ and $r = -0.149^{\text{NS}}$, respectively), indicating a limited role of pod size *per se* in resistance. In contrast, pod wall thickness, which ranged from 0.14 to 0.29 mm, was significantly negatively correlated with larval population ($r = -0.411^*$); the thickest pod walls were recorded in Phule G 1620-7-3 (0.29 mm) and L550 (0.27 mm), and the thinnest in RVSS G 139 (0.14 mm) and JG315 (0.15 mm). This agrees with Hossain *et al.* (2008) [12] and Lakra *et al.* (2018) [33], who reported that thicker pod walls were associated with lower pod damage, suggesting that pod wall thickness provides a mechanical barrier to larval penetration.

3.1.5 Seed arrangement and pod damage

All 37 germplasms exhibited a uniform single-row (uniseriate) arrangement of seeds within the pod, and this character could therefore not differentiate resistant from susceptible reactions. Pod damage caused by *H. armigera* ranged from 7.00 to 41.00 per cent; the lowest damage was recorded in GJG 2306 (7.00%), L550 (7.20%), IPC 2020-123 (9.40%), RKG 25-10 (11.00%) and Keonjhar chana 2 (13.00%), while the highest was recorded in RVSS G 139 (41.00%), GJG 2210 (35.00%), NBEG 1740 (31.00%), JGK 5 (29.20%) and GJG 2401 (28.80%) (Table 4). On the basis of the PRSR scale, IPC 2020-123 was categorised as resistant (Rating 3) and BDNG 220-61, Phule G 1620-7-3, Phule G-1705-8-20, Keonjhar chana 2 and BG 4078 as moderately resistant (Rating 4), whereas RVSS G 139 was categorised as highly susceptible (Rating 9).

Table 2. Trichome length and trichome density on leaf and pod in chickpea germplasm

S.No.	Coding	Trichome length on leaf (mm) - Glandular	Trichome length on leaf (mm) - Non-glandular	Trichome length on pod (mm) - Glandular	Trichome length on pod (mm) - Non-glandular	Trichome density (no./mm ²) - Leaf	Trichome density (no./mm ²) - Pod
1	BDNG 220-61	0.22	0.18	0.27	0.19	18.50	25.00
2	IPCB 2019-93	0.17	0.19	0.13	0.23	16.50	20.00
3	NBEG 1740	0.11	0.21	0.20	0.19	12.00	13.50
4	BG 4075	0.18	0.18	0.13	0.21	17.00	20.50
5	Phule G 1620-7-3	0.25	0.24	0.25	0.26	21.50	27.50
6	GLD 21009	0.13	0.19	0.10	0.20	18.50	17.00
7	KCD 25047	0.19	0.16	0.13	0.17	15.50	18.00
8	GDG 2314	0.11	0.18	0.14	0.19	20.00	20.50

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9	RVSS G 139	0.12	0.08	0.13	0.20	10.50	15.50
10	JG 2024-87	0.15	0.21	0.20	0.20	16.00	23.00
11	H 21-03	0.17	0.23	0.20	0.15	21.50	20.00
12	RVSS G 140	0.18	0.17	0.13	0.20	15.50	17.50
13	Phule G-1705-8-20	0.12	0.19	0.13	0.26	17.50	18.00
14	PG 425	0.11	0.17	0.16	0.24	17.50	17.50
15	IPC 2020-123	0.22	0.21	0.20	0.25	23.00	27.50
16	Keonjhar chana 2	0.17	0.16	0.18	0.18	13.50	14.50
17	GJG 2210	0.14	0.22	0.17	0.23	15.00	17.50
18	GJG 2306	0.18	0.28	0.14	0.28	25.50	27.00
19	BG 4078	0.13	0.21	0.13	0.20	21.00	23.50
20	Phule G-1705-2-9	0.29	0.18	0.21	0.19	15.00	23.00
21	GNG-2701	0.10	0.16	0.15	0.20	13.50	17.50
22	AKG-2240	0.14	0.20	0.12	0.25	19.50	18.50
23	IPC 2021-134	0.21	0.16	0.16	0.20	17.50	22.00
24	NBEG 1469	0.15	0.18	0.18	0.22	19.50	20.00
25	COC 1902	0.10	0.17	0.13	0.19	13.00	15.50
26	GJG 2401	0.17	0.12	0.13	0.23	18.00	20.00
27	RVSS G-154	0.22	0.18	0.17	0.19	17.00	20.50
28	BRC 2024-16	0.13	0.20	0.13	0.25	17.50	16.50
29	VCMH-24-5	0.17	0.22	0.16	0.20	15.50	16.50
30	RKG 25-10	0.17	0.21	0.18	0.23	19.00	20.50
31	JG 2025-101	0.14	0.22	0.17	0.26	21.00	22.00
32	RKGM 20-1	0.20	0.25	0.14	0.26	15.50	17.50
33	Sper annegiri	0.14	0.25	0.17	0.22	18.50	20.50
34	JGK 5	0.18	0.16	0.21	0.19	17.00	20.00
35	Phule G-0517	0.15	0.22	0.18	0.25	15.00	13.50
36	L550 (RC)	0.23	0.28	0.21	0.27	21.50	28.50
37	JG315 (SC)	0.10	0.17	0.14	0.20	16.00	15.50
S.E.(m)±		0.02	0.02	0.03	0.03	2.87	3.82
CD (5%)		0.05	0.04	0.06	0.06	5.83	7.76
CV		14.26	11.50	18.37	13.65	16.48	19.34

Table 3. Correlation coefficient between antixenosis characters of chickpea germplasms and larval population of gram pod borer, *Helicoverpa armigera* (Hubner), during rabi 2025-2026

S.No.	Antixenosis character	Correlation coefficient (r)		
1	Glandular trichome length on leaf	-0.357*	4	Non-glandular trichome length on pod -0.354*
2	Non-glandular trichome length on leaf	-0.541**	5	Trichome density on leaf -0.550**
3	Glandular trichome length on pod	-0.371*	6	Trichome density on pod -0.577**
			7	Pod length -0.238 NS
			8	Pod width -0.149 NS
			9	Pod wall thickness -0.411*

*Significant at 5% ($p = 0.05$); **Significant at 1% ($p = 0.01$); NS - Non-significant

Table 4. Plant type, pod width, pod wall thickness and pod damage (%) of representative resistant and susceptible chickpea germplasms during rabi 2025-2026

S.No.	Germplasm	Plant type	Pod width (mm)	Pod wall thickness (mm)	Pod damage (%)
1	GJG 2306	Spread	9.40	0.24	7.00 (R)
2	L550 (RC)	Semi-erect	8.20	0.27	7.20 (R)
3	IPC 2020-123	Spread	8.75	0.19	9.40 (R)
4	RKG 25-10	Erect	7.70	0.17	11.00 (R)
5	Keonjhar chana 2	Spread	9.65	0.21	13.00 (MR)
6	GJG 2401	Erect	7.55	0.18	28.80 (S)
7	JGK 5	Semi-erect	8.45	0.18	29.20 (S)
8	NBEG 1740	Semi-erect	8.35	0.19	31.00 (S)
9	GJG 2210	Erect	7.35	0.18	35.00 (S)
10	RVSS G 139	Erect	7.85	0.14	41.00 (HS)

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R- Resistant, MR- Moderately resistant, S- Susceptible, HS- Highly susceptible (based on per cent pod damage); mean pod length across germplasms ranged from 9.30 to 18.85 mm and was not significantly correlated with larval population.

3.2 Antibiosis resistance in chickpea germplasm

Based on field reaction and PRSR grading, fifteen chickpea germplasms of contrasting resistance and susceptibility were evaluated for total phenol, total soluble sugar, flavonoid, malic acid and tannin content, and correlated with larval population of *H. armigera* (Table 5, Table 6).

3.2.1 Total phenol content

Total phenol content ranged from 0.20 to 0.33 mg/g, being highest in BG 4078 and L550 (0.33 mg/g) and lowest in RVSS G 139 (0.20 mg/g). Correlation analysis revealed a highly significant negative association between phenol content and larval population ($r = -0.792^{**}$), the strongest among all the characters studied, indicating that higher phenol accumulation was associated with greater resistance. These results are in agreement with Sharma *et al.* (2005) [15], Kaur *et al.* (2016) [34], Golla *et al.* (2020) [14] and Reddy *et al.* (2022) [35], who reported that resistant chickpea germplasms possessed higher phenol content and lower pod damage. Phenolic compounds are oxidised to quinones, which bind with proteins and interfere with larval digestion, thereby reducing larval growth and contributing to antibiosis resistance.

3.2.2 Total soluble sugar content

Total soluble sugar (TSS) content ranged from 3.70 to 7.25 °Brix, being highest in RVSS G 139 (7.25 °Brix) and lowest in L550 (3.70 °Brix). Unlike the other biochemical characters, TSS showed a highly significant positive correlation with larval population ($r = 0.664^{**}$), indicating that higher sugar content favoured larval feeding and development. This finding is consistent with Kamakshi *et al.* (2008) [36]

and Sane *et al.* (2025) [16], who reported that susceptible germplasms generally possess higher sugar levels that enhance pod palatability and nutritional suitability for larval feeding, whereas lower soluble sugar content contributes to antibiosis resistance.

3.2.3 Total flavonoid content

Total flavonoid content ranged from 0.07 to 0.17 mg/g, being highest in L550 (0.17 mg/g) and lowest in JG315 (0.07 mg/g), with a highly significant negative correlation with larval population ($r = -0.697^{**}$). These results agree with Kaur *et al.* (2016) [34], Jaba *et al.* (2017) [37] and Reddy *et al.* (2022) [35], who reported negative associations between flavonoid content and pod damage. Flavonoids may act as antifeedants that impair larval digestion, growth and development, reducing the suitability of pods for *H. armigera* feeding.

3.2.4 Malic acid content

Malic acid content ranged from 0.70 to 1.48 per cent, being highest in GJG 2306 (1.48%) and lowest in JG315 (0.70%), and showed a significant negative correlation with larval population ($r = -0.544^{*}$). These results corroborate Lateef (1985) [38] and Yoshida *et al.* (1995) [39], who reported that resistant chickpea germplasms contained higher amounts of organic acids in leaf exudates, associated with reduced larval survival and pod damage.

3.2.5 Tannin content

Tannin content ranged from 0.62 to 1.50 mg/g, being highest in L550 (1.50 mg/g) and lowest in JG315 (0.62 mg/g), with a significant negative correlation with larval population ($r = -0.572^{*}$). These results are supported by Sharma *et al.* (2014) [40] and Kaur *et al.* (2016) [34], who reported that resistant chickpea cultivars possessed higher tannin levels along with reduced insect growth and pod damage, suggesting that tannins interfere with larval feeding and development, thereby contributing to antibiosis resistance.

Table 5. Total phenol, total soluble sugar, flavonoid, malic acid and tannin content of selected chickpea germplasms during rabi 2025-2026

S.No.	Germplasm	Total phenol (mg/g)	Total soluble sugars (°Brix)	Malic acid (%)	Flavonoids (mg/g)	Tannins (mg/g)
1	BDNG 220-61	0.28	5.05	1.38	0.10	0.92
2	BG 4075	0.23	6.95	0.77	0.11	0.73
3	Phule G 1620-7-3	0.30	4.45	0.93	0.16	1.00
4	RVSS G 139	0.20	7.25	0.95	0.10	0.93
5	Phule G-1705-8-20	0.30	4.75	1.20	0.13	0.65
6	IPC 2020-123	0.30	4.60	1.00	0.13	0.88
7	Keonjhar chana 2	0.32	4.75	1.15	0.11	0.75
8	GJG 2306	0.32	4.20	1.48	0.15	1.00
9	BG 4078	0.33	5.42	0.96	0.13	1.10
10	AKG-2240	0.25	5.45	0.85	0.13	0.83
11	GJG 2401	0.21	5.15	0.88	0.11	0.92
12	RKG 25-10	0.26	5.60	0.94	0.12	0.68
13	JGK 5	0.27	5.95	0.77	0.08	0.85
14	L550 (RC)	0.33	3.70	1.27	0.17	1.50
15	JG315 (SC)	0.26	6.10	0.70	0.07	0.62
S.E.(m)±	0.03	0.7	0.16	0.02	0.05	
CD (1%)	0.09	2.08	0.47	0.05	0.12	
CV	11.02	13.19	15.31	13.50	12.60	

Taken together, the morphological and biochemical results indicate that germplasms L550, GJG 2306, IPC 2020-123 and BG 4078 combined denser and longer trichomes, thicker pod walls, erect to compact plant type, higher phenol, flavonoid, malic acid and tannin contents, and lower soluble sugar content, with correspondingly lower larval population and pod damage. In contrast, RVSS G 139, GJG

2401, GJG 2210 and JG315 recorded shorter and sparser trichomes, thinner pod walls, lower defensive biochemical constituents and higher soluble sugar content, together with greater larval infestation and pod damage, confirming that antixenosis and antibiosis mechanisms act in a complementary manner to determine the overall resistance reaction of chickpea germplasm to *H. armigera*.

Table 6. Correlation coefficient between biochemical characters of chickpea germplasms and larval population of gram pod borer, *Helicoverpa armigera* (Hubner), during rabi 2025-2026

S.No.	Biochemical character	Correlation coefficient (r)
1	Total phenol	-0.792**
2	Total flavonoid	-0.697**
3	Total soluble sugar	0.664**
4	Malic acid	-0.544*
5	Total tannin	-0.572*

*Significant at 5% ($p = 0.05$); **Significant at 1% ($p = 0.01$)

4. Conclusions

Evaluation of antixenosis resistance revealed significant variation among 37 chickpea germplasms for trichome length and density on leaves and pods, and for pod wall thickness, all of which were negatively correlated with larval population of *H. armigera*, whereas pod length and pod width had no significant influence. Germplasms L550, GJG 2306 and IPC 2020-123, possessing longer and denser trichomes and thicker pod walls, recorded the lowest pod damage and can serve as sources of antixenosis resistance. Evaluation of antibiosis resistance among fifteen selected germplasms showed that higher total phenol, flavonoid, malic acid and tannin contents, and lower total soluble sugar content, were associated with reduced larval population, with total phenol showing the strongest association ($r = -0.792^{**}$). L550, GJG 2306 and BG 4078 exhibited the most favourable biochemical profiles. Germplasms combining favourable antixenosis and antibiosis attributes, particularly L550, GJG 2306 and IPC 2020-123, represent promising donor sources that may be utilised in chickpea breeding programmes aimed at developing *H. armigera*-resistant cultivars.

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