



RESEARCH ARTICLE

Screening of chickpea (*Cicer arietinum* L.) genotypes for resistance to gram pod borer (*Helicoverpa armigera* Hubner) in north west alluvial plain of Bihar

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Abstract

A field experiment on screening of chickpea genotypes was evaluated for resistance to *Helicoverpa armigera* during rabi 2023–24 at the Agricultural Research Farm, RPCAU, Pusa. A total of fifteen genotypes, including the susceptible check P-3043, were evaluated for larval incidence during vegetative, 50 % flowering and 50 % maturity stages, pod damage and yield performance. The study found significant variation in larval populations of the gram pod borer during these stages. The larval incidence was lowest during the vegetative stage, ranging from 0.47 to 1.27 larvae plant⁻¹, medium to high in the flowering stage (0.73 to 2.20 larvae plant⁻¹) and peaked during 50 % maturity stage (1.87 to 3.67 larvae plant⁻¹). Among all the screened genotypes, BG 4051 had the lowest overall mean larval population (1.02 larvae plant⁻¹), while P-3043 had the highest overall mean larval population (2.38 larvae plant⁻¹). The range of pod damage was from 15.04 % (BG 4051) to 27.40 % (P-3043), demonstrating the role of morphological features like trichomes and pod wall thickness in imparting resistance. Grain yield ranged from 803.1 to 1138.7 kg ha⁻¹, with BG 4051 (1138.7 kg ha⁻¹), KCK-2 (1118.7 kg ha⁻¹) and HK 21–13 (1048.9 kg ha⁻¹) generating better yields. Based on the pest resistance susceptibility rating scale, eight genotypes were classified as moderately resistant, five as intermediate and two as susceptible. The findings indicated that the presence of promising sources of resistance, with BG-4051, KCK-2 and HK 21–13, warrants further screening for use in breeding programmes and they can be recommended for multilocation testing and subsequently variety release. These resistant genotypes can be integrated into host plant resistance-based IPM strategies, thereby reducing dependence on chemical insecticides in chickpea cultivation.

Keywords: BG 4051; *Helicoverpa armigera*; pod damage; PRSR; vegetative stage

Introduction

Chickpea (*Cicer arietinum* L.) is an agriculturally and nutritionally significant legume, often known as the king of pulses and commonly referred to by diverse names including bengal gram, ceci bean, chana and garbanzo bean (1, 2). After peas and soybeans, chickpeas are the third most significant pulse, accounting for roughly 15 % of global pulse production in 2022 (3). Chickpea grains contain a variety of nutrients in their composition. The main nutrients are carbohydrates (50–58 %), protein (15–22 %), moisture (7–8 %) and fat (3.8–10.20 %) (4, 5). Chickpeas have many different types of carbohydrates, which include prebiotics, such as sugar alcohols and fructo-oligosaccharides, as well as raffinose family oligosaccharides and resistant starch (6). The health advantages of chickpeas may include a decreased risk of cancer, diabetes and heart disease (7). Chickpea plays a critical role in fixing nitrogen by symbiosis with rhizobia bacteria (8, 9). Additionally, its straw has high fodder value (10).

In India, chickpea is cultivated on 10.74 Mha and production was 13.54 Mt with a productivity of 1261 kg ha⁻¹. In Bihar, the chickpea is cultivated on an area of 0.051 Mha and produces 0.054 Mt with a productivity of 1053 kg ha⁻¹ (11). However, chickpea production is constrained by different insect pest viz., gram pod borer, aphid, cutworm, semilooper, bruchid and leaf miner, etc. (12). Among these, gram pod borer *Helicoverpa armigera* (Hubner) (Lepidoptera: Noctuidae) is a multivoltine, extremely polyphagous and cosmopolitan pest. The destructive stages of the insect are its larval stages, which feed on more than 182 distinct host plants, including chickpea, pigeon pea, cotton, maize and tomato (13). The damaging potential of *H. armigera* on chickpea causes, on average, 30–40 % pod damage (14, 15) and under severe infestations, complete crop failure (16). Farmers predominantly depend on insecticides for pod borer management. Insecticides are expensive and their indiscriminate use has led to the

development of pesticide resistance, environmental contamination and adverse ecological disruption (17–19). Effective management tactics become crucial during the early stages of the crop in order to prevent substantial pod damage and consequent reductions in seed yield (20,21).

Considering the need for environmentally friendly pest management tactics, it is essential to adopt strategies that minimise ecological disruption. Among these, the development of promising resistant varieties forms a strong foundation for integrated pest control programmes (22). The deployment of resistant varieties offers a consistent and cumulative reduction in pest population without imposing high additional costs on farmers. Hence, breeding techniques should prioritise the identification, characterisation and utilisation of genetic mechanisms that confer durable resistance to the gram pod borer. The development of improved chickpea cultivars resistant to pod borer can be effectively achieved when reliable sources of resistance are available, coupled with efficient and practical screening methods that ensure strong selection pressure.

Materials and Methods

Experimental site and crop details

The study was conducted during rabi, 2023–24 at the Agricultural Research Farm, Dr Rajendra Prasad Agricultural University, Pusa. The site is positioned at 25.9° N latitude and 85.5° E longitude, with an elevation of 53 m (173.9 ft) above sea level. It lies within agro-climatic zone-1, specifically the North West Alluvial Plain of Bihar and is part of the command area of the Gandak River. The soil in this region exhibits a texture range from loamy to sandy loam. The study was conducted to evaluate the fifteen promising genotypes by comparing them with the popular susceptible chickpea variety P-3043. The chickpea genotypes were grown in a plot size of 3 m × 1 m with a spacing of 30 cm (row to row) and 10 cm (plant to plant) with a Randomised Block Design with three replications. To ensure a good crop, all the standard cultural and agronomic practices such as land preparation with ploughing, application of recommended doses of fertilisers, timely irrigation and manual weeding were maintained throughout the cropping season no insecticides were applied in any form during the entire crop period.

Observational procedure

Observations on the number of larvae plant⁻¹ were counted from five randomly tagged plants in each plot at different growth stages, such as the vegetative stage, 50 % flowering stage and 50 % maturity stage. Pod damage (%) was recorded by counting the damaged pods from five randomly selected plants in each plot during the crop maturity stage. The following formula was used to

$$\text{Pod damage} = \frac{\text{No of infested pods}}{\text{Total no of pods}} \times 100 \quad (\text{Eqn. 1})$$

Table 1. Pest resistance susceptible rating scale and categories

PRS (%)	Grade	Pest resistance susceptible rating (PRSR)
100	1	Immune
75 to 99	2	Highly resistant
50 to 75	3	Resistant
25 to 50	4	Moderately resistant
10 to 25	5	Intermediate
-10 to 10	6	Equal to susceptible check
-25 to -10	7	Moderately susceptible
-50 to -25	8	Susceptible
< -50	9	Highly susceptible

PRS = Pest resistance/ susceptible

determine the per cent pod damage (Eqn. 1).

$$\text{PRS (\%)} =$$

$$\frac{\% \text{ PD in susceptible check} - \% \text{ PD in test genotype}}{\% \text{ PD in susceptible check}} \times 100 \quad (\text{Eqn. 2})$$

Per cent of pod damage of chickpea genotypes was compared with that of the susceptible check. Subsequently, the test genotypes were graded using the following formula (23). Where, PD = pod damage, PRS = pest resistance/susceptibility

The pest resistance per cent was converted to the 1–9 PRS scale (24) (Table 1). Yield data, initially recorded in kg per plot, were converted to kg ha⁻¹.

Statistical analysis

The data collected throughout the experiment were statistically analysed using the analysis of variance technique (ANOVA) for randomised block design as per the standard method (25). The data on larval population were transformed with a square root transformation and the pod damage data were transformed by Arcsine transformation method. Differences among treatment means were compared using the critical difference (CD) test at $P = 0.05$ with the help of using computer software OPSTAT (26). Correlation relationships among larval population, pod damage and yield were also analysed using OPSTAT software.

Results and Discussion

Larval population of the gram pod borer during various crop stages

The data on the number of larvae plant⁻¹ count was recorded at the vegetative stage, 50 % flowering stage and 50 % maturity stage of chickpea genotypes have been represented in Table 1 and Fig.1. Larval population was significantly varied across these growth stages. During the vegetative stage, larval density of the gram pod borer ranged from 0.47 larvae plant⁻¹ in BG 4051 to 1.20 larvae plant⁻¹ in AKGK-1802 comparing to the susceptible variety P-3043 (1.27 larvae plant⁻¹), as the differences were within the CD value of 0.15. The CV of 7.76 % indicated good experimental precision. During the 50 % flowering stage, the mean larval population gradually increased. The least larval population were documented in genotype BG 4051 (0.73 larvae plant⁻¹) while the highest larval population were noticed in AKGK-1802 (1.87 larvae plant⁻¹) against susceptible check P-3043 (2.20 larvae plant⁻¹) with a CD value of 0.14 and CV of 6.01 %, indicating reliable treatment comparisons. During the 50 % maturity stage of the crop, the mean larval population was higher because it mainly feeds on the seed inside

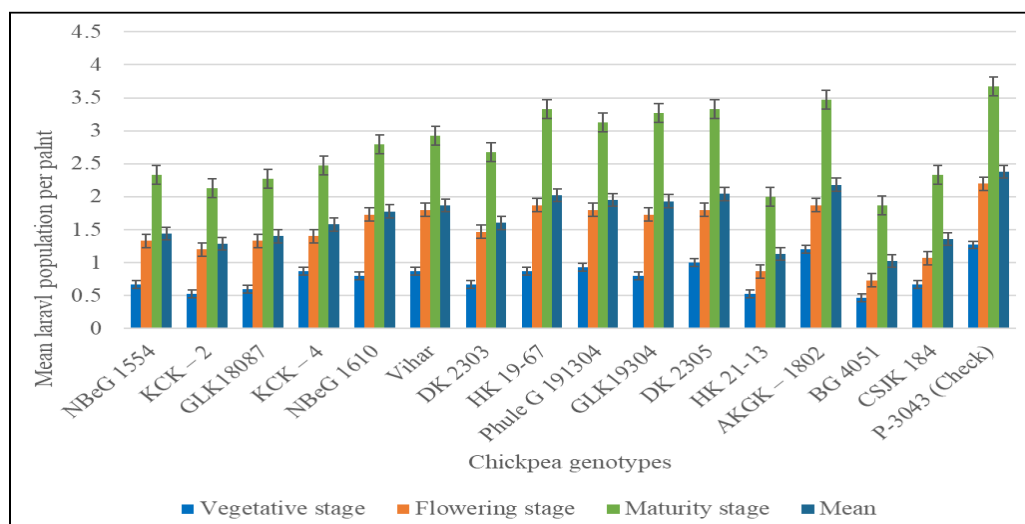


Fig. 1. Mean larval population of gram pod borer at different growth stages of chickpea on different chickpea genotypes during rabi 2023–24.

the pod. Larval population ranged from 1.87 larvae plant⁻¹ in BG 4051 to 3.47 larvae plant⁻¹ in AKGK-1802 comparing to susceptible check P-3043, 3.67 larvae plant⁻¹, with differences within the CD value of 0.20. The CV (6.57 %) reflected acceptable experimental variability. The overall mean of larval density of *H. armigera* on chickpea ranged from 1.02 to 2.38 larvae plant⁻¹ (Table 2 and Fig.1). The mean data analysis indicated the lowest mean larval density in genotype BG 4051 (1.02 larvae plant⁻¹), followed by HK 21–13 (1.13 larvae plant⁻¹), which were statistically similar to each other. The maximum pooled mean larval density was noted in genotype check P-3043 (2.38 larvae plant⁻¹) with a CD value ($P=0.05$) of 0.08 and a CV of 6.20%.

The present study revealed significant variation among chickpea genotypes in their response to infestation by *H. armigera* across different crop growth stages. The larval population significantly increased from the vegetative stage to the maturity stage, indicating stage-specific susceptibility of the crop. In the present investigation, the larval population was lower during the vegetative stage but higher during 50 % maturity stage. Similar trends were observed in previous studies, where the mean larval population was 0.2–1.8 larvae plant⁻¹ during the vegetative stage but the highest was recorded during 50 % maturity (1.17–3.66 larvae plant⁻¹) due to the availability of reproductive structures preferred by the larvae (27, 28). This study also showed similarity

with the prior studies indicated low larval density during the vegetative stage (0.2–1.8 larvae plant⁻¹), moderate larval population at the 50 % flowering stage (0.4–3.6 larvae plant⁻¹) and the highest larval population at the 50 % maturity stage, ranging from 1.17–3.8 larvae plant⁻¹ (29).

Pooled mean larval population of gram pod borer in chickpea ranged from 1.69–3.65 larvae plant⁻¹ (30). These findings are in close agreement with the results of the present study, which recorded a larval population ranging from 1.02–2.38 larvae plant⁻¹. Genotypes (BG 405, HK 21–13 and KCK-2) characterized by shorter trichomes with higher density were found to be less infested by the gram pod borer, which was consistent with the findings of earlier reports (31, 32), that trichomes have negative effect on *H. armigera* development and life cycle.

Pod damage (%)

Pod damage (%) of *H. armigera* ranged from 15.04–27.40 % (Table 3 and Fig.2). The minimum of pod damage (%) was noted in the genotype BG 4051 (15.04 %). The maximum per cent pod damage was recorded in check P-3043 (27.40 %), followed by AKGK-1802 (26.83 %), DK 2305 (25.91 %), HK 19–67 (24.10 %) and GLK19304 (23.73 %) with CD at 5 % (2.54) and CV of 7.27 %, indicating the more consistent and reliable precision.

Table 2. Mean larval population of gram pod borer on different chickpea genotypes during rabi 2023–24

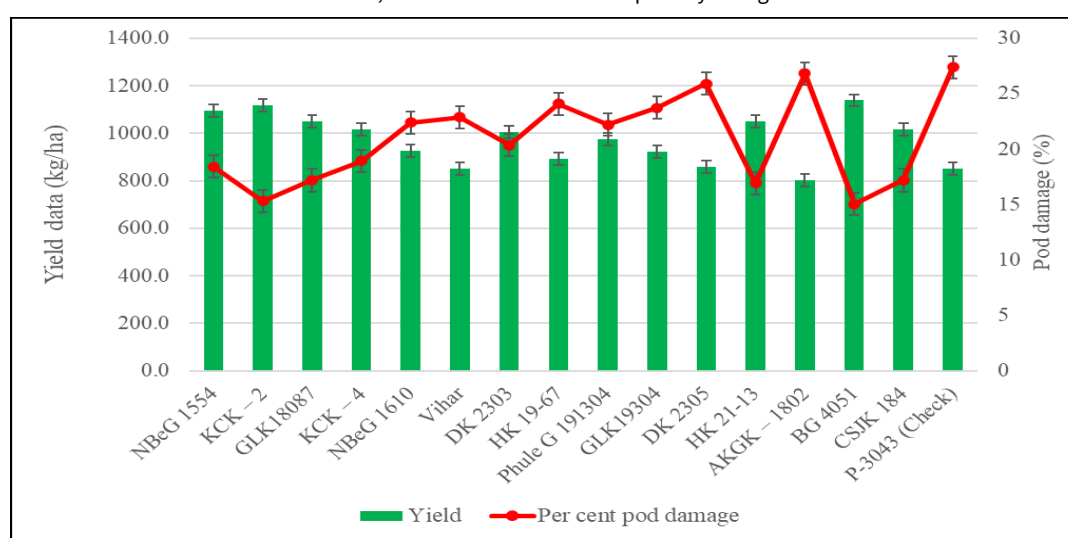
S. No	Genotypes	Mean larval population per plant			Mean
		Vegetative stage	50 % flowering	50 % maturity	
1	NBeG 1554	0.67 (1.08)*	1.33 (1.35)	2.33 (1.68)	1.44 (1.37)
2	KCK-2	0.53 (1.02)	1.20 (1.30)	2.13 (1.62)	1.29 (1.31)
3	GLK18087	0.60 (1.05)	1.33 (1.35)	2.27 (1.66)	1.40 (1.35)
4	KCK-4	0.87 (1.16)	1.40 (1.37)	2.47 (1.72)	1.58 (1.42)
5	NBeG 1610	0.80 (1.14)	1.73 (1.49)	2.80 (1.82)	1.78 (1.48)
6	Vihar	0.87 (1.17)	1.80 (1.52)	2.93 (1.85)	1.87 (1.51)
7	DK 2303	0.67 (1.07)	1.47 (1.40)	2.67 (1.78)	1.60 (1.42)
8	HK 19–67	0.87 (1.16)	1.87 (1.54)	3.33 (1.96)	2.02 (1.55)
9	Phule G 191304	0.93 (1.20)	1.80 (1.52)	3.13 (1.91)	1.95 (1.54)
10	GLK19304	0.80 (1.14)	1.73 (1.49)	3.27 (1.94)	1.93 (1.52)
11	DK 2305	1.00 (1.22)	1.80 (1.52)	3.33 (1.96)	2.04 (1.57)
12	HK 21–13	0.53 (1.02)	0.87 (1.16)	2.00 (1.58)	1.13 (1.25)
13	AKGK-1802	1.20 (1.30)	1.87 (1.54)	3.47 (1.99)	2.18 (1.61)
14	BG 4051	0.47 (0.98)	0.73 (1.10)	1.87 (1.54)	1.02 (1.21)
15	CSJK 184	0.67 (1.08)	1.07 (1.25)	2.33 (1.68)	1.36 (1.34)
16	P-3043 (Check)	1.27 (1.33)	2.20 (1.64)	3.67 (2.04)	2.38 (1.67)
SEm (±)		(0.05)	(0.05)	(0.07)	(0.03)
CD ($p=0.05$)		(0.15)	(0.14)	(0.20)	(0.08)
CV (%)		7.76	6.01	6.57	6.20

*Figures in parentheses are $\sqrt{x} \pm 0.5$ transformed values.

Table 3. Pest resistant susceptibility rating (PRSR) of chickpea genotypes based on % pod damage during rabi, 2023–24

S. No	Genotypes	(%) Pod damage	PRSR	Category	Yield (kg/ha)
1	NBeG 1554	18.43 (25.43)*	4.0	Moderately resistant	1095.0
2	KCK-2	15.33 (23.05)	4.0	Moderately resistant	1118.7
3	GLK18087	17.20 (24.50)	4.0	Moderately resistant	1050.5
4	KCK-4	18.93 (25.79)	4.0	Moderately resistant	1015.0
5	NBeG 1610	22.40 (28.25)	5.0	Intermediate	927.9
6	Vihar	22.90 (28.59)	5.0	Intermediate	850.3
7	DK 2303	20.37 (26.83)	4.0	Moderately resistant	1005.0
8	HK 19-67	24.10 (29.40)	5.0	Intermediate	893.3
9	Phule G 191304	22.20 (28.11)	5.0	Intermediate	976.5
10	GLK19304	23.73 (29.15)	5.0	Intermediate	923.3
11	DK 2305	25.91 (30.60)	6.0	Equal to susceptible check	860.3
12	HK 21-13	16.93 (24.30)	4.0	Moderately resistant	1048.9
13	AKGK-1802	26.83 (31.20)	6.0	Equal to susceptible check	803.1
14	BG 4051	15.04 (22.82)	4.0	Moderately resistant	1138.7
15	CSJK 184	17.20 (24.50)	4.0	Moderately resistant	1016.7
16	P-3043 (Check)	27.4 (31.56)	-	-	851.0
SEm ($\pm$)		(0.88)	-	-	54.03
CD ($p = 0.05$)		(2.54)	-	-	156.52
CV (%)		7.27	-	-	9.61

*Figures in parenthesis are arc sine transformed values, PRSR: Pest resistant susceptibility rating.

**Fig. 2.** Pod damage and yield data on different chickpea genotypes during rabi 2023–24.

The pod formation stage is considered the most susceptible growth stage of chickpea to infestation by *H. armigera*. During this stage, the larvae mainly feed on developing pods and seeds, resulting in direct yield loss and significant pod damage. The percentage of pod damage found across genotypes in the current study was in close accordance with previous findings. Research found that where pod damage ranged from 5.33 % to 31.33 % across diverse chickpea lines (33–35). The findings are varied from previous reports, indicating 64.88 % to 78.48 % pod damage in 2017–2018 and 68.22 % to 80.47 % pod damage in 2018–2019 (30, 36).

Yield

Grain yield of chickpea genotypes ranged from 803.1 to 1138.7 kg ha⁻¹ (Table 3 and Fig.2). The maximum grain yield was recorded in genotype BG 4051 (1138.7 kg ha⁻¹) followed by KCK-2 (1118.7 kg ha⁻¹), NBeG 1554 (1095.0 kg ha⁻¹), GLK18087 (1050.5 kg ha⁻¹), HK 21–13 (1048.9 kg ha⁻¹) and DK 2303 (1005 kg ha⁻¹) at CD value ($P = 0.05$) of 156.52 and CV of 9.61 %. The minimum grain yield was recorded in AKGK-1802 (803.1 kg ha⁻¹), followed by Vihar (850.3 kg ha⁻¹), DK 2305 (860.3 kg ha⁻¹) and HK 19–67 (893.3 kg ha⁻¹) respectively, which were statistically at par with each other. The check P-3043 got the yield of 851 kg ha⁻¹.

Genotypes BG 4051, KCK-2 and NBeG 1554 had the highest yield due to lower larval populations and less pod damage. Though both genotypes (GLK 18087 and CSJK 184) had similar amounts of pod damage, GLK 18087 produced a higher yield than CSJK 184 due to its greater number of pods per plant. The yield performance is closely in line with the previous results that genotype IC 269347 exhibited the highest yield of 1166.66 kg ha⁻¹ due to less pod damage inferred by high trichome density (37). These results are also in line with studies were reported on average grain yield of chickpea genotypes ranged from 870 to 1730 kg ha⁻¹, further supporting the wide range of yield variability among tested genotypes (29, 38).

Correlation analysis among larval population, pod damage and yield

Correlation analysis indicated a highly significant and strong positive relationship between larval population and pod damage ($r = 0.973^{***}$), demonstrating that increased larval density directly resulted in higher pod damage (Table 4). Yield exhibited a strong and significant negative correlation with larval population ($r = -0.909^{***}$) and pod damage ($r = -0.947^{***}$). The stronger negative association between pod damage and yield suggests that pod damage is a direct determinant of economic loss.

Table 4. Correlation Matrix of larval population of *H. armigera* and pod damage against yield

Parameter	Larval population	Pod damage (%)	Yield (kg/ha)
Larval population	1	0.973***	-0.909***
Pod damage (%)	0.973***	1	-0.947***
Yield (kg/ha)	-0.909***	-0.947***	1

*** Correlation is significant at 0.001 level, ** Correlation is significant at 0.01 level, * Correlation is significant at 0.05 level.

These findings are in line with earlier studies that the relationship between larval population of gram pod borer and pod damage had a significant positive correlation, while yield had a significant negative correlation with both parameters (larval population and pod damage) at the 0.01 level of significance (39). Overall, these results indicate high infestation levels cause significant losses in yield and point out the need to identify and promote resistant genotypes of chickpea for effective management of *H. armigera*.

Categorisation of chickpea genotypes based on pest resistance susceptibility rating (PRSR) against *H. armigera*

PRSR was determined for each of the genotypes by comparing them to check P-3043, as given in the materials and methods. The pest resistance susceptibility rating of the present investigation ranged from 4 to 6 (Table 3). Among all the genotypes eight genotypes viz., NBeG 1554, KCK-2, GLK18087, KCK-4, DK 2303, BG 4051, CSJK 184 and HK 21-13 were ranked under 'moderately resistant' which was graded of 4 in pest susceptibility rating scale (Table 3) and five genotypes NBeG 1610, Vihar, HK 19-67, GLK19304 and Phule G 191304 showed pest susceptibility rating of 5 which falls under the category 'Intermediate'. Two genotypes, such as DK 2305 and AKGK-1802, got the rating scale of 6, which came under the category of 'Equal to susceptible check'.

Gram pod borer pod infestation was compared among all the chickpea genotypes with susceptible check (ICC 3137) and resistant check (ICCL 86111), the PRSR was found to be 3 to 8 (29). The above findings are also similar to prior reports, indicating that the pod incidence of the different genotypes was compared with the susceptible check ICC3137, the PRSR was found to be 3 and 4 (27).

Conclusion

The present investigation revealed significant variation among chickpea genotypes in their response to infestation by *Helicoverpa armigera*. The above study concluded that, based on the larval population, pod damage (%) and PRSR scale, genotypes BG 4051, KCK-2 and HK 21-13 were found to be least affected by pod borer as compared to the susceptible check (P-3043). These genotypes could be exploited as a source of resistance for the varietal development of chickpea germplasm against *H. armigera*. Further study is required to explore the role of biophysical and biochemical plant traits, as well as the impact of climate change, on the resistance of the tested genotypes against *H. armigera*.

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Authors' contributions

GB contributed to conceptualisation, methodology, investigation, formal analysis, writing original draft. RP contributed to resources, formal analysis, validation and supervision. SKMP contributed to visualisation, writing, review and editing. DLD contributed to formal analysis, writing, review and editing. KPR contributed to writing, review and editing. GMI contributed to data analysis and review. All the 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

The authors used Grammarly only for checking grammar and sentence structure during the preparation of this manuscript. No content was generated by AI tools. After using Grammarly, the authors carefully reviewed and edited the entire manuscript themselves to ensure clarity and correctness. The authors take full responsibility for the content of the manuscript.

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