



RESEARCH ARTICLE

The influence of developmental characteristics of the pulse beetle, *Callosobruchus chinensis* (L.), on assessing resistance among chickpea genotypes

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Received: 28 August 2025; Accepted: 16 December 2025; Available online: Version 1.0: 24 March 2026

Cite this article: Gutti A, Manoj KT, Sashanka SD, Raghabananda N, Biswajit J, Subhadarsini P, Priyanka N. The influence of developmental characteristics of the pulse beetle, *Callosobruchus chinensis* (L.), on assessing resistance among chickpea genotypes. Plant Science Today. 2026; 13(sp1): 1-6. <https://doi.org/10.14719/pst.11510>

Abstract

The pulse beetle, *Callosobruchus chinensis* (L.), is one of the most destructive insect pests of stored chickpea grains. The present study evaluated the effect of developmental characteristics of *C. chinensis* on 15 chickpea genotypes under controlled laboratory conditions to identify resistance or susceptibility levels. Significant variation was observed among genotypes with respect to oviposition, development, adult emergence and grain weight loss. The highest number of eggs was recorded on Phule vishwaraj (142.00 eggs/20 g) and the lowest on NBeG-49 (20.33 eggs/20 g). Grain weight loss ranged from 70.92 % on Vijay to 20.33 % on JG-11. Adult emergence percentage was maximum on NBeG-119 (83.33 %) and minimum on NBeG-49 (53.33 %). The developmental period varied from 25.67 days on Krupa to 35.33 days on Vijay. The growth index ranged between 1.51 on NBeG-49 and 3.17 on NBeG-119. Based on growth index and adult emergence, Digvijay, Vishal, Vijay, NBeG-49, NBeG-3 and PDKV Kanchan were classified as less susceptible or moderately resistant, while Phule vishwaraj and NBeG-119 were categorised as highly susceptible. These findings highlight the importance of genotype-based resistance in chickpea, which can be exploited in breeding programmes to reduce post-harvest losses and strengthen integrated pest management (IPM) strategies against *C. chinensis*.

Keywords: adult emergence; *Callosobruchus chinensis*; chickpea genotypes; developmental period; growth index; susceptibility

Introduction

Pulses are a vital component of the vegetarian diet in India due to their high protein content and nutritional value (1). Among them, chickpea (*Cicer arietinum* L.), popularly known as “Bengal gram” or “chana,” occupies a premier position as the “King of Pulses.” It is an important winter legume crop, valued for its protein (18–22 %), carbohydrates (52–70 %), fats (4–10 %), essential minerals and vitamins (2). In India, chickpea is cultivated on about 98.86 lakh hectares, producing 107.37 lakh tonnes with a productivity of 1086 kg/ha. The major producing states include Madhya Pradesh, Rajasthan, Maharashtra and Karnataka, while Odisha also contributes significantly to chickpea cultivation (3, 4).

Despite its importance, chickpea grains suffer heavy post-harvest losses due to storage pests, diseases and environmental factors. Among insect pests, the pulse beetle, *Callosobruchus chinensis* (L.) (Coleoptera: Chrysomelidae), is the most destructive, causing up to 55.7 % damage to stored pulses under severe infestation (5). This pest infests both cultivated and wild legumes, damaging crops in the field as well as in storage (6).

Conventional control measures largely rely on insecticides, but these approaches pose environmental risks and can lead to resistance development. Hence, host plant resistance offers a safe, economical and sustainable management strategy.

The present investigation was undertaken to evaluate the resistance or susceptibility of 15 chickpea genotypes against *C. chinensis* based on developmental and biological parameters under controlled laboratory conditions. Understanding such genotype-pest interactions will aid in developing resistant varieties and strengthen integrated pest management (IPM) strategies for chickpea.

Materials and Methods

The study was conducted during 2021–2023 at the Storage Entomology Laboratory, Department of Entomology, College of Agriculture, Odisha University of Agriculture and Technology. A laboratory culture of pulse beetle, *C. chinensis*, was maintained on chickpea seeds in glass jars (25 × 15 × 10 cm) containing 500 g of

grain. Approximately 500 adults obtained from the stock culture were released for oviposition. The chickpea genotype 'Digvijay' was used to maintain the culture. Prior to use, the seeds were sieved, cleaned and sterilised in a hot air oven at 55 ± 1 °C for 1 hr to eliminate hidden infestations. After 48 hr, the adults were removed and the jars were covered with muslin cloth and maintained under laboratory conditions of 30 ± 1 °C temperature and 70 % relative humidity.

A total of 15 chickpea genotypes were evaluated for resistance against *C. chinensis*. These included Digvijay, Phule vikrant, Phule vikram, Virat, Krupa, Vishal, PDKV kanchan, Vijay, Phule vishwaraj, NBeG-49, NBeG-3, NBeG-119, NBeG-47, JG-11 and Bhubaneswar local. The seeds of these genotypes were obtained from MPKV, Rahuri, Maharashtra and RARS, Nandyal Andhra Pradesh. The evaluation was carried out using the "no-choice" test method. For each genotype, 20 g of seed was placed in a glass jar (15 × 5 cm) and 5 pairs of freshly emerged adults were released for oviposition. The beetles were removed after 72 hr. The experiment was conducted in a completely randomised block design (CRBD) with 3 replications and observations were recorded on various biological and developmental parameters of the insect.

The number of eggs laid was counted 3 days after insect release with the help of a magnifying glass. The emergence of adults was recorded daily from the day of first emergence up to 45 days and the percentage of adult emergence was calculated as the total number of adults emerged in relation to the total number of eggs laid. To determine seed weight loss, the initial and final weights of 20 g seed samples were recorded after the completion of adult emergence and the difference was expressed as a percentage of the initial weight (7). The developmental period of the insect was assessed as the total duration from egg to adult emergence, including the egg, larval and pupal stages. The growth index was

calculated as the ratio of adult emergence percentage to the mean developmental period and genotypes were categorised into different susceptibility groups (8). Genotypes were categorised into different susceptibility groups based on adult emergence and growth index (Table 1). Genotypes with less than 60 % emergence and a growth index below 2.35 were categorised as less susceptible or moderately resistant, those with 60–80 % emergence and a growth index between 2.35 and 3.0 were considered moderately susceptible and those with more than 80 % emergence and a growth index above 3.0 were classified as highly susceptible.

Results

The results of the present study revealed significant variation among chickpea genotypes with respect to oviposition, developmental period, adult emergence, seed weight loss and growth index of *C. chinensis*. The number of eggs laid varied considerably, with the maximum of 142.00 eggs recorded on Phule vishwaraj and the minimum of 20.33 eggs on NBeG-49. Intermediate levels of oviposition were recorded on NBeG-119 (132.33 eggs), Virat (108.33 eggs) and NBeG-47 (114.67 eggs), while genotypes such as Vishal, PDKV kanchan and NBeG-3 recorded relatively lower egg numbers.

The developmental period of the insect also differed among genotypes, ranging from the shortest duration of 25.67 days on Krupa to the longest period of 35.33 days on Vijay. Similar extended development was also observed in NBeG-49 (35.33 days) and Digvijay (35.00 days). The detailed developmental parameters of *C. chinensis* on each genotype are presented in Table 2. The percentage of adult emergence was highest on NBeG-119 (83.33 %) and Phule vishwaraj (81.11 %), whereas the lowest emergence was recorded on NBeG-49 (53.33 %).

Table 1. Classification of genotypes based on adult emergence and growth index

Category	Adult emergence (%) for total eggs	Growth index	Genotypes
1	<60 %	<2.35	Less susceptible /moderately resistant
2	60–80 %	2.35–3.0	Moderately susceptible
3	>80 %	>3.0	Highly susceptible

Table 2. Development and growth of pulse beetle (*C. chinensis*) reared on different chickpea varieties in storage

Varieties	Chickpea genotypes	Adult longevity (days)*	Mean no. of adults emerged	Adult emergence % **	Weight loss % **	Growth index
T ₁	Digvijay	7.33 (7.0–8.0)	17.67	58.89 (50.13)	23.57 (28.99)	1.70
T ₂	Phule vikrant	8.00 (7.0–9.0)	20.33	67.78 (55.42)	22.33 (28.17)	2.43
T ₃	Phule vikram	7.67 (7.0–9.0)	19.33	64.44 (53.43)	32.27 (34.44)	2.39
T ₄	Virat	8.00 (7.0–9.0)	23.00	76.67 (61.15)	42.63 (40.74)	2.81
T ₅	Krupa	9.00 (8.0–10.0)	22.00	73.33 (58.94)	28.87 (32.32)	2.86
T ₆	Vishal	10.00 (9.0–11.0)	16.67	55.56 (48.19)	23.53 (28.65)	1.64
T ₇	PDKV Kanchan	10.00 (9.0–11.0)	17.00	56.67 (48.84)	34.12 (35.00)	1.70
T ₈	Vijay	7.67 (7.0–8.0)	17.33	57.78 (49.48)	70.92 (57.37)	1.64
T ₉	Phule Vishwaraj	10.33 (10.0–11.0)	24.33	81.11 (64.26)	66.37 (54.56)	3.05
T ₁₀	NBeG-49	8.00 (7.0–9.0)	16.00	53.33 (46.91)	28.02 (31.93)	1.51
T ₁₁	NBeG-3	8.00 (7.0–9.0)	16.33	54.44 (47.55)	20.33 (25.83)	1.59
T ₁₂	NBeG-119	9.67 (9.0–10.0)	25.00	83.33 (65.97)	28.92 (32.46)	3.17
T ₁₃	NBeG-47	9.33 (9.0–10.0)	23.33	77.78 (61.89)	33.13 (35.07)	2.88
T ₁₄	JG-11	9.00 (8.0–10.0)	21.67	72.22 (58.20)	20.20 (26.28)	2.50
T ₁₅	Bhubaneswar local	10.00 (9.0–10.0)	20.67	68.89 (56.10)	35.36 (36.43)	2.47
	SE(m)±	0.516	0.501	1.056	3.382	0.099
	CD (p = 0.05)	1.49	1.44	3.05	9.76	0.29

*Figures in parentheses are log transformed values, mean of 3 replications **Figures in parentheses are range values. Each figure is the mean of 3 replications.

Seed weight loss showed wide variation, with the maximum loss of 70.92 % recorded on Vijay and the minimum loss of 20.33 % on JG-11. Adult emergence, weight loss and growth index values for all genotypes are summarised in Table 3. The patterns of adult emergence (%) and associated weight loss among chickpea genotypes are illustrated in Fig. 1. High weight loss was also noted on Phule vishwaraj (66.37 %), while genotypes such as NBeG-3 (20.33 %) and Digvijay (23.57 %) showed considerably lower losses. Adult longevity ranged from 7.33 days on Digvijay to 10.33 days on Phule vishwaraj.

The growth index of *C. chinensis* varied from a minimum of 1.51 on NBeG-49 to a maximum of 3.17 on NBeG-119. The variation in total developmental period and corresponding growth index across genotypes is presented in Fig. 2. The complete correlation matrix is given in Table 4. Based on the classification, Digvijay, Vishal, Vijay, NBeG-49, NBeG-3 and PDKV kanchan were grouped under less susceptible or moderately resistant genotypes, while Phule vishwaraj and NBeG-119 were categorised as highly susceptible. A complete categorisation of all genotypes is presented in Table 5. Other genotypes fell into the moderately susceptible group.

Correlation analysis indicated that growth index was negatively associated with developmental period, whereas it was positively correlated with adult emergence percentage, number of eggs laid and percentage seed weight loss.

Discussion

The findings of the present study demonstrate that chickpea genotypes differ significantly in their influence on the biological performance of *C. chinensis*, suggesting that host seed characteristics play a decisive role in pest establishment. Higher oviposition on genotypes such as Phule vishwaraj and NBeG-119 may be attributed to seed traits like smooth testa, larger seed size and possibly higher carbohydrate and lipid content that provide better conditions for egg adhesion and subsequent larval penetration. In contrast, reduced oviposition on genotypes like NBeG-49 and NBeG-3 may be due to harder seed coats, presence of secondary metabolites, or reduced surface area available for egg laying. Similar host-mediated differences in ovipositional

Table 3. Evaluation of chickpea varieties for resistance against pulse beetle, *C. chinensis*

Tr. No.	Varieties	Mean number of eggs laid*	Mean development period (Days)**			
			Egg	Larva	Pupa	Development period
T ₁	Digvijay	81.33 (1.91)	5.67 (5.0–6.0)	22.33 (21.0–23.0)	7.00 (6.0–8.0)	35.00 (32.0–37.0)
T ₂	Phule vikrant	89.33 (1.95)	5.33 (5.0–6.0)	16.33 (16.0–17.0)	6.33 (6.0–7.0)	28.00 (27.0–30.0)
T ₃	Phule vikram	90.00 (1.95)	5.33 (5.0–6.0)	16.33 (16.0–17.0)	5.33 (5.0–6.0)	27.00 (26.0–28.0)
T ₄	Virat	108.33 (2.03)	5.33 (4.0–7.0)	15.67 (15.0–16.0)	6.33 (6.0–7.0)	27.33 (26.0–29.0)
T ₅	Krupa	101.33 (2.01)	5.33 (5.0–6.0)	13.67 (13.0–14.0)	6.67 (6.0–7.0)	25.67 (25.0–26.0)
T ₆	Vishal	60.67 (1.78)	4.67 (4.0–5.0)	22.67 (22.0–23.0)	6.33 (6.0–7.0)	34.00 (33.0–35.0)
T ₇	PDKV kanchan	69.33 (1.84)	5.67 (5.0–6.0)	21.00 (20.0–22.0)	6.67 (6.0–7.0)	33.33 (33.0–34.0)
T ₈	Vijay	75.67 (1.88)	5.67 (5.0–6.0)	22.33 (22.0–23.0)	7.33 (7.0–8.0)	35.33 (35.0–36.0)
T ₉	Phule vishwaraj	142.00 (2.15)	5.00 (4.0–6.0)	16.33 (15.0–18.0)	5.33 (5.0–6.0)	26.67 (25.0–29.0)
T ₁₀	NBeG-49	20.33 (1.31)	5.33 (5.0–6.0)	23.00 (22.0–24.0)	7.00 (6.0–8.0)	35.33 (34.0–37.0)
T ₁₁	NBeG-3	46.67 (1.67)	5.67 (5.0–6.0)	22.67 (21.0–24.0)	6.00 (5.0–7.0)	34.33 (34.0–35.0)
T ₁₂	NBeG-119	132.33 (2.12)	5.00 (4.0–6.0)	15.67 (15.0–16.0)	5.67 (5.0–6.0)	26.33 (25.0–28.0)
T ₁₃	NBeG-47	114.67 (2.06)	5.33 (5.0–6.0)	14.33 (14.0–15.0)	7.33 (7.0–8.0)	27.00 (26.0–28.0)
T ₁₄	JG-11	98.67 (1.99)	6.33 (6.0–7.0)	15.67 (14.0–17.0)	7.00 (6.0–8.0)	29.00 (28.0–31.0)
T ₁₅	Bhubaneswar local	96.00 (1.98)	5.67 (5.0–6.0)	15.67 (15.0–17.0)	6.67 (6.0–7.0)	28.00 (27.0–30.0)
	SE(m)±	0.011	0.430	0.564	0.413	0.839
	CD (p=0.05)	0.03	1.24	1.63	1.19	2.42

*Figures in parentheses are range values

**Figures in parentheses are angular transformed value

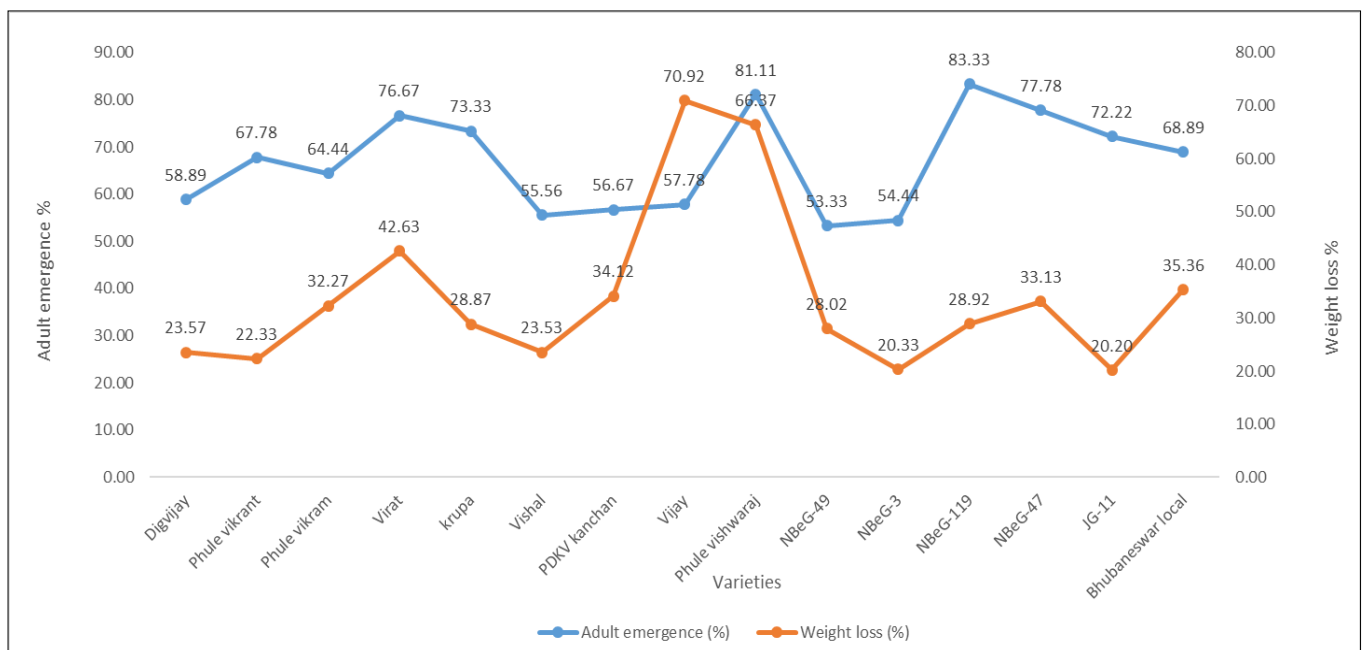


Fig. 1. Evaluation of chickpea genotypes with adult emergence (%) and weight loss (%).

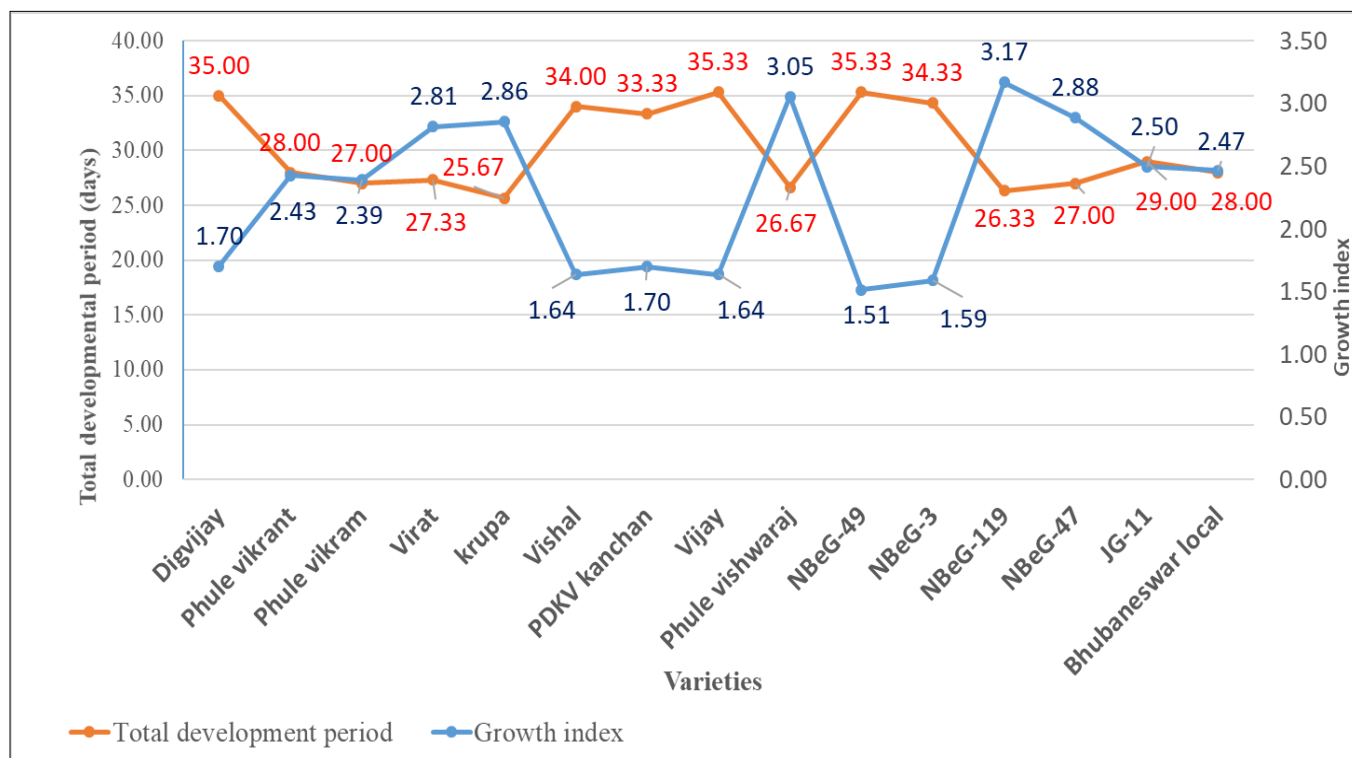


Fig. 2. Evaluation of chickpea genotypes with total developmental period and growth index of pulse beetle.

Table 4. Correlation matrices of growth index and growth parameters of pulse beetle, *C. Chinensis* on chickpea varieties

Variable	Weight loss (%)	No. of eggs	Adult emergence (%)	Developmental period	Growth index
Growth index	0.154**	0.907**	0.983**	-0.955**	
Developmental period	-0.043 ^{NS}	-0.817**	-0.891**		
Adult emergence (%)	0.205 ^{NS}	0.932**			
No. of eggs	0.341 ^{NS}				
Weight loss (%)					

Values are Pearson's correlation coefficients (r). ** = significant at $p \leq 0.01$; * = significant at $p \leq 0.05$; NS = non-significant. Developmental period is in days; weight loss and adult emergence are in percent; number of eggs indicates eggs laid. Growth index is derived from adult emergence and developmental period.

Table 5. Categorisation of chickpea varieties based on growth index

S. No.	Variety	Adult emergence (%)	Growth index	Category
1	Digvijay	<60	<2.35	Less susceptible/ Moderately resistance
2	Phule vikrant	60–80	2.35–3.0	Moderately susceptible
3	Phule vikram	60–80	2.35–3.0	Moderately susceptible
4	Virat	60–80	2.35–3.0	Moderately susceptible
5	Krupa	60–80	2.35–3.0	Moderately susceptible
6	Vishal	<60	<2.35	Less susceptible/ Moderately resistance
7	PDKV kanchan	<60	<2.35	Less susceptible/ Moderately resistance
8	Vijay	<60	<2.35	Less susceptible/ Moderately resistance
9	Phule vishwaraj	>80	>3.0	Highly susceptible
10	NBeG-49	<60	<2.35	Less susceptible/ Moderately resistance
11	NBeG-3	<60	<2.35	Less susceptible/ Moderately resistance
12	NBeG-119	>80	>3.0	Highly susceptible
13	NBeG-47	60–80	2.35–3.0	Moderately susceptible
14	JG-11	60–80	2.35–3.0	Moderately susceptible
15	Bhubaneswar local	60–80	2.35–3.0	Moderately susceptible

Adult emergence is expressed in percent. Growth index categories are based on thresholds: <2.35 = less susceptible/moderately resistant; 2.35–3.0 = moderately susceptible; >3.0 = highly susceptible.

preference of bruchids have been highlighted in earlier studies (9–12).

The duration of the developmental period is a critical indicator of host suitability. Insects reared on resistant genotypes such as Vijay and NBeG-49 exhibited prolonged development, which could be explained by poor nutrient assimilation, presence of digestion inhibitors, or low seed moisture that slows down larval growth. Conversely, shorter developmental durations observed on susceptible genotypes such as Krupa and NBeG-119 indicate that these seeds provided optimal nutrition and a favourable microenvironment for larval development. These results agree with earlier findings that developmental plasticity in *C. chinensis* is strongly influenced by host genotype and associated biochemical composition (13, 14).

Adult emergence percentage is directly linked to the survival and reproductive success of the beetle. In the present study, resistant genotypes not only reduced oviposition but also suppressed adult emergence, possibly due to higher larval mortality within the seed. Similar reductions in emergence have been reported in chickpea and pigeon pea, where resistant genotypes limited the completion of the beetle's life cycle (15, 16). Since adult emergence strongly correlates with population build-up, restricting this parameter through host resistance is of immense practical value.

Seed weight loss is an economic measure of damage and clearly differentiates between resistant and susceptible varieties. Maximum losses in Vijay and Phule vishwaraj suggest high seed utilisation efficiency by larvae, while minimal losses in JG-11 and NBeG-3 reflect seed defense mechanisms that either impair larval feeding or increase mortality. Resistance could involve both physical (hard seed coat, compact cotyledons) and chemical factors (phenolics, tannins, or enzyme inhibitors). These observations align with previous findings, who emphasised the role of seed traits in conferring resistance against bruchids (17).

The growth index, which combines developmental duration and adult emergence, proved to be a reliable screening tool for categorising genotypes. Resistant genotypes recorded low growth indices due to longer development and reduced emergence, whereas susceptible genotypes recorded high values, reflecting rapid development and higher survival. Similar trends were reported in chickpea and cowpea (18, 19). The correlation analysis further strengthens these findings, as the growth index exhibited strong positive associations with oviposition, adult emergence and seed weight loss, but a negative relationship with developmental duration. These associations indicate that genotypes which delay insect development tend to restrict population growth and reduce seed damage, thereby contributing to resistance (20, 21).

From a pest management perspective, the identification of moderately resistant genotypes such as Digvijay, Vishal, Vijay, NBeG-49, NBeG-3 and PDKV kanchan holds promise for integration into breeding programmes. These genotypes can provide valuable resistance genes for developing improved cultivars. On the other hand, highly susceptible genotypes like Phule vishwaraj and NBeG-119 can serve as susceptible checks in screening programmes. The use of resistant varieties is particularly important for resource-poor farmers, as it offers a cost-effective and environmentally safe alternative to chemical insecticides.

Incorporating host resistance into IPM strategies will thus reduce post-harvest losses, enhance storage stability and improve food security.

Conclusion

The present study established significant genotypic differences in the susceptibility of chickpea varieties to *C. chinensis*. Genotypes such as Digvijay, Vishal, Vijay, NBeG-49, NBeG-3 and PDKV kanchan exhibited moderate resistance by restricting oviposition, prolonging developmental period and reducing adult emergence and seed weight loss, while Phule vishwaraj and NBeG-119 were found to be highly susceptible. The growth index proved to be a reliable parameter for categorising genotypes and demonstrated strong associations with other biological traits of the beetle. These resistant genotypes can serve as valuable resources in resistance breeding programmes and contribute to eco-friendly IPM strategies aimed at minimising storage losses in chickpea.

Acknowledgements

The authors express gratitude to the Department of Entomology, College of Agriculture, Odisha University of Agriculture and Technology, for providing laboratory facilities and technical assistance. The authors also acknowledge Mahatma Phule Krishi Vidyapeeth (MPKV), Rahuri and Regional Agricultural Research Station (RARS), Nandyal, for supplying chickpea genotypes used in this study.

Authors' contributions

GA conducted the experiment, collected data and drafted the initial manuscript. MKT supervised the experimental work and contributed to data interpretation. SSD conceptualised the study, guided the research design and critically revised the manuscript. RN assisted in statistical analysis and interpretation of results. BJ, SP and PN contributed to literature review, manuscript refinement and editing. All authors read and approved the final manuscript.

Compliance with ethical standards

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

Ethical issues: None

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

During the preparation of this work, the authors used OpenAI's ChatGPT to assist in language refinement. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the final manuscript.

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

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