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Variation in Host Suitability and Development of *Lasioderma serricorne* (Fab.) (Coleoptera: Ptinidae) on Tobacco Seed

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Authors' contributions

This work was carried out in collaboration among all authors. Author BSJ planned and conducted the experiments, data analysis and prepared the first draft of the manuscript. Author TM revised the procedure and planning for conducting these experiments and corrected the first draft of the manuscript. Author KPR provided guidance and facilities for the conduct of the experiments. Author KPR verified the results and helped to revise the manuscript. Author LKP supported in conducting the biochemical analyses and revised the manuscript. Author LE aided in seed colour estimation and verified the results and revised the manuscript. Author AP planned the biochemical analyses of tobacco seed and revised the manuscript. Author JPB conducted the biochemical analyses especially nitrogen assays and revised the manuscript. All authors read and approved the final manuscript.

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Original Research Article

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Abstract

The cigarette beetle, *Lasioderma serricorne* (Fabricius), is an important pest of stored tobacco, but differences in its development on seeds of individual tobacco varieties remain insufficiently documented. This study evaluated host suitability and seed damage among 25 tobacco varieties using a no-choice assay arranged in a completely randomised design with three replications. For each variety, adult beetles were introduced into seed samples, and fecundity, adult emergence, mean developmental period, growth index and percentage seed-weight loss were recorded. Seed biochemical and biophysical characteristics were also evaluated, with analysis of variance, correlations and principal component analysis used to assess varietal differences and associations. Mean fecundity was 210.24 eggs and did not differ significantly among varieties (P = .118). Adult emergence, developmental period, growth index and seed-weight loss varied significantly. Overall adult emergence averaged 72.10%, the mean developmental period was 77.34 days, and mean seed-weight loss was 10.06%. Izmir exhibited the highest seed-weight loss (14.57%), followed by CTRI Sulakshana and DCT-4 (14.53% each). CTRI Sulakshana recorded the shortest mean developmental period (62.91 days), while Podali, Dharla and Banket A1 showed comparatively lower seed-weight losses. Correlation and principal component analyses indicated associations among infestation measures, but no single measured seed trait fully accounted for host suitability. These findings support variety-specific monitoring priorities under the tested storage conditions.

Keywords: Cigarette beetle; tobacco seed; host suitability; adult emergence; growth index; seed weight loss.

1. Introduction

The cigarette beetle *Lasioderma serricorne* (Fab.) (Coleoptera: Ptinidae) infests a wide variety of dried food and non-food stored commodities. This insect pest consumes plant-based stored products such as spices, grains, cereal products, legumes, nuts, oilseeds, dried fruits, cocoa, herbs, and animal-origin products, *such as* dry fish, fishmeal, meat, leather, pet food and preserved insect specimens, and industrially packaged foods, such as biscuits, vermicelli and spice mixes (Arbogast *et al.*, 2000). *Lasioderma serricorne* has been transferred from the family Anobiidae to Ptinidae following the revision of coleopteran family-group names by Bouchard *et al*. (2011). A recent review also identifies *L. serricorne* as a pest of diverse stored commodities, highlighting its relevance to the protection of stored agricultural materials (Karnavat *et al*., 2025).

The ability of *L. serricorne* to survive on herbarium materials, Indian Ayurvedic medicines and pyrethrum-based insecticides indicates its potential as an industry-level pest. In particular, *L. serricorne* infests high-value products of commerce such as tobacco and tobacco products (Ashworth, 1993) making it an industry-level pest. According to Edde and Phillips (2022) and Manzelli (1986), the major and most destructive post-harvest insect pest in the tobacco industry, compared with the tobacco moth, is *L. serricorne***.** For stored-product pests more generally, improved detection and monitoring have been discussed as components of effective management (Nisar *et al*., 2025).

Tobacco seeds are tiny, range from light to dark brown in colour, and have a thick, reticulate testa bearing concave interspaces (Adams & Toll, 2000). According to Bharathi *et al.* (2002), the annual rate of increase of *L. serricorne* on flue-cured Virginia (FCV) tobacco seed is 2.135×10^5 times. Recent experimental work has shown that the development and population growth of *L. serricorne* can differ among tobacco varieties and under simulated seasonal storage conditions (Saengarkhom *et al*., 2026). Molecular evidence further implicates detoxification-associated genes in larval tolerance of tobacco, although this does not establish comparative susceptibility among tobacco seeds (Zafar *et al*., 2026). Specifically, the type of tobacco seed may influence the mean development period and host suitability of *L. serricorne* due to various underlying biophysical and biochemical factors of tobacco seed. However, variation in *L. serricorne* emergence, developmental performance, and associated weight loss among tobacco seed varieties remains insufficiently documented. This gap warrants a controlled comparison of tobacco seed varieties under the no-choice conditions examined in the present study. Hence, it was necessary to identify the seed of the tobacco variety most favourable to *L. serricorne* to aid in decision-making for monitoring and management. A no-choice method was used to assess the host suitability of seeds from 25 tobacco varieties.

2. Materials and Methods

***L. serricorne* Mass Culture:** Thirty pairs of *L. serricorne* were released in 250 g of wheat flour fortified with 5 per cent yeast. The culture was maintained under a 16:8-hour light:dark photoperiod and subcultured every 2–3 months to maintain a continuous supply of beetles.

Seed Sample Collection: Fresh tobacco seeds of various varieties were collected from various locations across the country through the ICAR-National Institute for Research on Commercial Agriculture and its research stations and through the centres of the All India Network Project on Tobacco (AINPT). The seeds received from various locations were disinfested in a hot air oven at 45 ± 2 °C for 3 hours to destroy hidden infestations. After sufficient cooling to room temperature, the seeds were stored hygienically in sealed plastic containers with proper labelling at room temperature. Clean and intact seeds were selected for the experiments after mechanical separation.

No-choice Test Design: Newly emerged, one-day-old adults of *L. serricorne* were used from the laboratory culture to conduct the no-choice test. This was intended to assess the influence of seeds from 25 tobacco varieties on the growth of *L. serricorne.* For each variety, three individual observation units or replications were maintained in a completely randomized design (CRD). For each of the selected high-yielding tobacco varieties, 100 g of seed sample was placed in each plastic container, with three replications. Ten pairs of freshly emerged adult beetles were released into each container. The adults of *L. serricorne* were removed after an oviposition period of five days and a 50 g subsample was transferred to a small plastic bottle, which was then covered with muslin cloth secured by a rubber band to observe the first day of adult emergence (Madhumathi, 1997). Both the main samples and subsamples were then kept undisturbed until adult emergence (Chaithanya *et al.*, 2023) at a temperature of 30 ± 2 °C and 70 ± 2% relative humidity. The daily numbers of emerging adults were used to calculate percentage emergence, mean developmental period, and growth index using the standard formulae given by Howe (1971). Percentage weight loss was also calculated for all the samples. The biophysical and biochemical parameters of the tobacco seeds were also estimated and correlated with the beetle infestation parameters.

Mean Development:

$$AV = \frac{\sum(N \times D)}{T}$$

where,

AV is the Mean developmental period (days)
N - Number of adults emerged on each day
D - Day of adult emergence from day of release
T - Total number of adults emerged during the experiment

Growth Index:

Growth index = E/ AV

where,

E - Per cent adult emergence
AV - Mean developmental period (days)

Biochemical Parameters: The biochemical quality parameters of tobacco seed, *namely* nicotine, reducing sugars, chlorides and nitrogen were estimated using an Auto-Analyzer (AA3; Bran + Luebbe, Germany) following established methods (Hanumantha Rao *et al.,* 1980; Harvey *et al*., 1969; Prasad *et al*., 2022).

Biophysical Parameters:

Seed Colour: Seed colour was quantified through colorimetry using a handheld colorimeter (Konica Minolta, Germany) to obtain CIELAB (Commission Internationale de l'Éclairage, or International Commission on Illumination, L*a*b*). The colourimeter was initially calibrated using a standard white tile. Readings were taken for each seed sample from three replications, placed in a petri dish above the centre of uniformly spread seeds (Mathiazhagan *et al.*, 2024). Using the three coordinate values, chroma (C*) and hue angle (h°) were calculated using the standard formulae given below:

$$C^* = \sqrt{a^{*2} + b^{*2}}$$
$$h^\circ = \tan^{-1}\left(\frac{b^*}{a^*}\right)$$

Seed Biometrics: The seed length, width, and other biometric traits were measured with a trinocular compound microscope (Carl Zeiss Primostar 3) at 2× magnification after placing tobacco seeds on a slide. A minimum of 50 observations were taken to arrive at the mean seed dimensions, *namely* seed length, seed width, and the seed length-to-width ratio. These measurements were correlated with the number of eggs laid by *L. serricorne*. Correlation analysis was conducted among *L. serricorne* infestation parameters and seed quality parameters.

All statistical analyses, including one-way ANOVA, were performed using Microsoft Excel and R software version 4.5.1 (R Core Team, 2025) after suitable transformations, taking into account normality tests and residual diagnostic plots. Correlations among the variables were examined, and principal component analysis (PCA) was conducted through R software to identify the major set of variables affecting host suitability.

3. Results and Discussion

L. serricorne is a major storage pest of tobacco and was found to infest almost all the varieties of tobacco. However, there were significant differences among seeds from different varieties in terms of suitability to the beetles.

Infestation and Developmental Traits: Among the 25 tobacco varieties evaluated, the mean fecundity was 210.24 eggs. A one-way ANOVA showed no significant variation in the fecundity of *L. serricorne* on seeds from different varieties ($F(24,50) = 1.49$, $P = .118$). This may reflect the requirement for *L. serricorne* to reproduce on the available resource when no alternative is provided.

However, CTRI Sulakshana recorded the highest fecundity (230.33 eggs), followed by Siri (222.00), GCT-3 (218.00), Banket A1 (217.00), and Izmir (216.67). The lowest fecundity was observed in HDBRG and Nandyala Pogaku-1 (196.00), followed by A119 (198.00) and CTRI Vijetha (201.33). Bharathi *et al.* (2002) mentioned that the potential fecundity of *L. serricorne* on tobacco seed was 24.72 eggs per female, which could be extrapolated to 247.2 eggs per 10 females, which is consistent with the observed results of this study.

The number of emerging adults was highest in CTRI Sulakshana (193.67 beetles), Izmir (186.33), Yasini (168.67), DCT-4 (166.33) and GABT-11 (160.00), indicating greater susceptibility and variation among varieties ($F(24,50) = 3.95$, $P < .001$). In contrast, Podali (121.33), Dharla (133.67), Nandyala Pogaku-1 (135.33), Banket A1 and CTRI Vijetha (136.33 each) recorded the lowest emergence.

Adult emergence percentage ranged from 58.13 to 85.99%, with a mean of 72.10%, with the highest values in Izmir (85.99%), CTRI Sulakshana (84.31%), Yasini (78.14%) and DCT-4 (77.07%). The lowest emergence occurred in Podali (58.13%), Banket A1 (62.83%), Dharla (65.24%) and CTRI Vijetha (67.36%) ($F(24,50) = 4.59$, $P < .001$).

The mean developmental period was shortest in CTRI Sulakshana (62.91 days), followed by Izmir (70.91), GCT-3 (71.37), Vedaganga-1 (71.45) and DCT-4 (71.64 days) ($F(24,50) = 24.26$, $P < .001$). The overall mean developmental period was 77.34 days.

The growth index ranged from 0.64 to 1.34, with a mean of 0.94 ($F(24,50) = 14.98$, $P < .001$). CTRI Sulakshana (1.34) and Izmir (1.21) recorded the highest indices, followed by DCT-4 (1.08), Yasini (1.06) and GABT-11 (1.04).

Seed weight loss ranged from 2.65 to 14.57%, with a mean of 10.06% ($F(24,50) = 53.40$, $P < .001$). Among the varieties listed, the highest weight loss was recorded in Izmir (14.57%), CTRI Sulakshana and DCT-4 (14.53% each), Yasini (13.87%) and GABT-11 (12.43%), whereas Podali (2.65%), Dharla (3.40%) and Banket A1 (3.90%) recorded the lowest losses. Similarly, Agrawal *et al.* (1981) recorded a weight loss of 8.85% in turmeric due to *L. serricorne***.** Joseph (1992) reported a weight loss of 13.01% in dry ginger and 17.97% in turmeric with a positive correlation with the *L. serricorne* population.

Hence, higher emergence, shorter developmental periods and greater growth indices indicated increased susceptibility, while weight loss provided a measure of varietal damage.

Biochemical Parameters: Nicotine content ranged from 0.00 to 0.117%, with the highest concentration in DCT-4 (0.117%), followed by Dharla (0.037%), Izmir (0.018%) and Nandyala Pogaku-2 (0.016%) ($F(24,50) = 36.11$, $P < .001$). Nicotine was undetectable in CTRI Vijetha, Abirami and Podali, while most other varieties contained 0.01% or less, suggesting a limited association between nicotine content and beetle susceptibility. Nitrogen content ranged from 3.87 to 4.55%, with the highest value in CTRI Sulakshana (4.55%), a highly susceptible variety. Reducing sugar content also varied across the varieties according to the one-way ANOVA ($F(24,50) = 73.74$, $P < .001$). It was highest in Dharla (1.21%), despite its moderate infestation, indicating no consistent linear relationship with susceptibility. Chloride content was highest in DCT-4 (0.26%), compared with the overall mean of 0.11%, while GABT-11, Vedaganga-1, Nandyala Pogaku-2 and Lanka Special recorded the lowest chloride levels (0.06%) ($F(24,50) = 69.43$, $P < .001$).

Nearly 90 per cent of the total alkaloid content in tobacco is nicotine, while nornicotine, anatabine and anabasine make up the remaining 10 per cent (Sisson & Severson, 1990). It has also been established that nicotine is produced in the plant roots and transported to the shoot system; hence, there is a decrease in levels of nicotine from root to leaf to seed. Accordingly, a variety with a low nicotine content in its leaves would have a much lower nicotine level in its seeds. Edde (2019) reported that the sugar content in the leaf of flue-cured, Turkish, Cuban and Puerto Rico, Connecticut Broadleaf and Havana, Pennsylvania, dark-fired varieties, and Burley tobacco gradually decreases as nicotine content increases. Baliota *et al.* (2022) reported that leaves of low-nicotine Burley tobacco had a negative impact on the populations of *L. serricorne* suggesting their unsuitability for the growth of this pest. Adequate sugar and starch contents in tobacco leaves may contribute to the reproductive fitness of the insect (Farnham *et al.*, 2007; Hori *et al*., 2011; Mahroof & Phillips, 2007; Saeed *et al.*, 2008). However, no such linear relationship was observed in the tobacco seed.

Biophysical Parameters:

Seed Colour: The varieties showed considerable variation in seed colour parameters. Fig. 1 shows the spread of these varieties on a colour space chart, where varieties V8 (DCT-4), V9 (Dharla) and V13 (GCT-3) formed a group distinct from all other varieties. The varieties DCT-4, Dharla and GCT-3 recorded lower a* ($F(24,50) = 53.87$, $P <.001$), b* ($F(24,50) = 105.82$, $P < .001$), and chroma ($F(24,50) = 86.59$, $P < .001$), with relatively high hue angles (0.39–0.45) ($F(24,50) = 31.98$, $P < .001$). GCT-3 recorded the lowest lightness (L* = 20.85) and differed significantly from other varieties ($F(24,50) = 21.21$, $P < .001$). Seed colour alone may not explain varietal preference, as this was a no-choice assay; however, the variation in colour can be visualised.

Seed Dimensions: There was significant variation ($P < .05$) in the dimensions of seeds from different varieties. DCT-4 recorded the largest seed dimensions (1573.55 µm in length and 1232.93 µm in width), with a seed length-to-width ratio of 1.28. This variety also recorded higher infestation levels.

Seed Moisture: The highest moisture content was recorded in Dharla (12.93%), Gajapati (12.03%) and Podali (11.80%), whereas CTRI Sulakshana (7.20%), Banket A1 (7.50%) and Lanka Special (7.60%) had lower moisture levels. These variations suggest that seed moisture may contribute to differences among varieties, although its relationship with susceptibility requires further statistical evaluation.

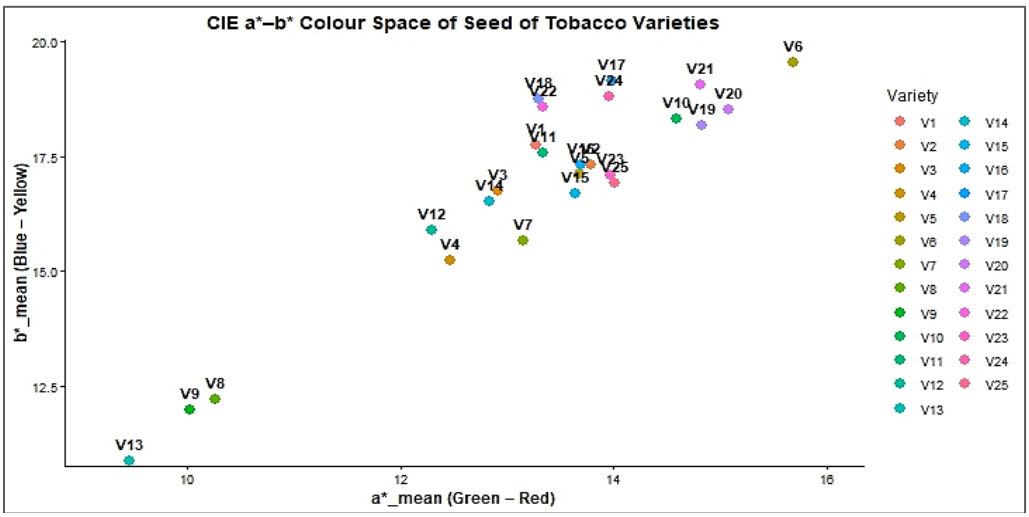

Fig. 1. Seed colour distribution of tobacco in a CIE colour space[V1 (A119); V2 (Abirami); V3 (Banket A1); V4 (CTRI Naveena); V5 (CTRI Sreshta); V6 (CTRI Sulakshana); V7 (CTRI Vijetha); V8 (DCT-4); V9 (Dharla); V10 (FCH 222); V11 (GABT11); V12 (Gajapati); V13 (GCT-3); V14 (GT-7); V15 (HDBRG); V16 (I737); V17 (Izmir); V18 (Kurnool Natu); V19 (Lanka Special); V20 (Nandyala Pogaku-1); V21 (Nandyala Pogaku-2); V22 (Podali); V23 (Siri); V24 (Vedaganga-1) and V25 (Yasini)]

Relationships amongst Infestation Parameters: Percentage weight loss was strongly correlated with the growth index (r = 0.81, R^2 = 0.65, *P* < .001). The growth index and mean developmental period (r = −0.86, R^2 = 0.74, *P* < .001) were strongly negatively correlated (Fig. 2).

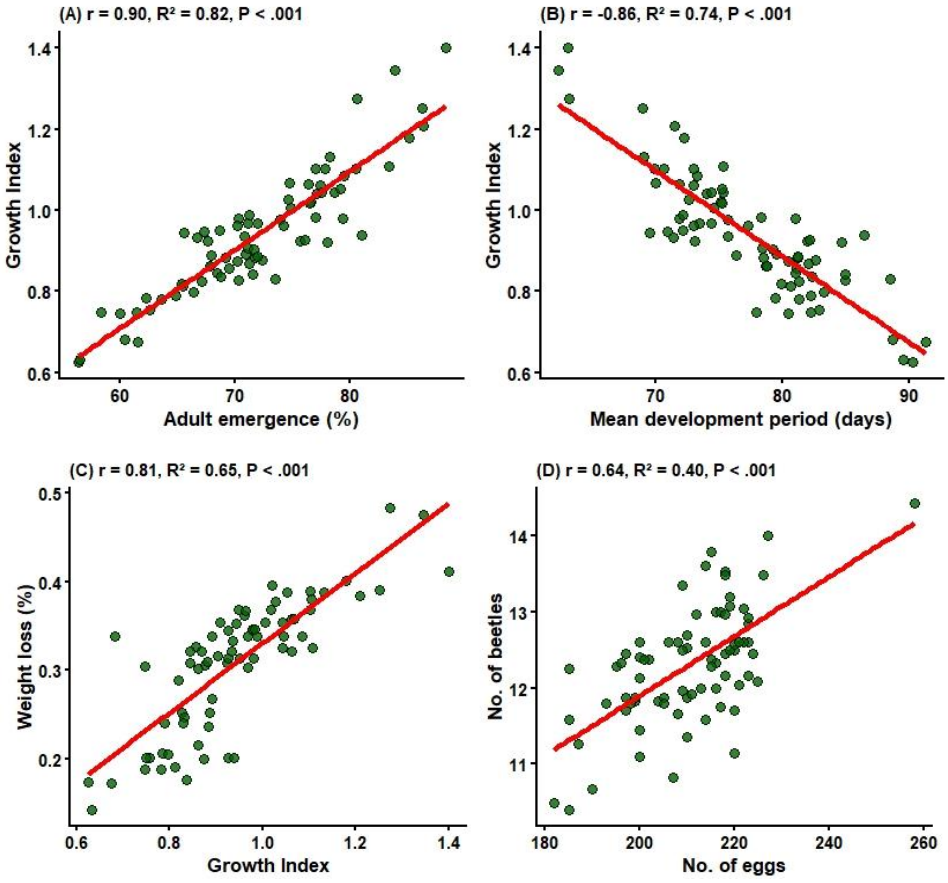

Fig 2. Correlation amongst the *L. serricorne* infestation parameters

The growth index was also strongly correlated with emergence (r = 0.90, R^2 = 0.82, *P* <.001).

Principal Component Analysis (PCA): To complement the correlation analysis, PCA was conducted on the infestation and biochemical parameters to identify the major patterns of variation among seeds. Seed colour was excluded because in this no-choice study, there was no opportunity for *L. serricorne* to select a particular colour. The scree plot (Fig. 3) showed a sharp decline in explained variance up to the third component, after which the curve flattened. The first two principal components had eigenvalues of 5.36 and 3.40 and explained 38.3% and 24.3% of the total variance, respectively, accounting for 62.6% cumulatively. The third component added 10.9%, bringing the cumulative variance to 73.5%. Principal components with eigenvalues greater than 1 (PC1 to PC4) together explained 80.7% of the variance. PC1 and PC2 were therefore retained for interpretation and were presented in the biplot (Fig. 4).

PC1 was predominantly associated with the *L. serricorne* growth index (17.42%), number of beetles (17.05%), emergence percentage (15.66%), mean developmental period (15.23%) and weight loss (14.70%). The major contributors to PC2 were chlorides (22.09%), seed width (20.88%), seed length (19.50%), reducing sugars (12.57%), and seed moisture (8.86%), followed by nicotine (7.06%). Hence, these were the major variables associated with the infestation level and host suitability.

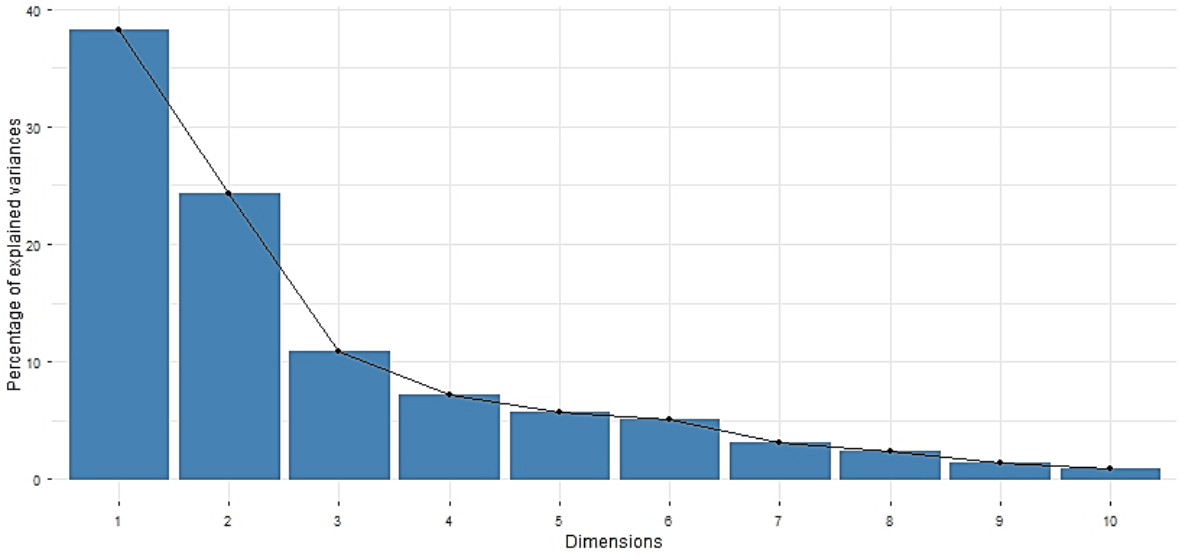

Fig. 3. Scree plot of the principal component analysis (PCA) of infestation and biochemical parameters on tobacco seed. Bars show the percentage of variance explained by each of the first ten principal components, and the line connects these values

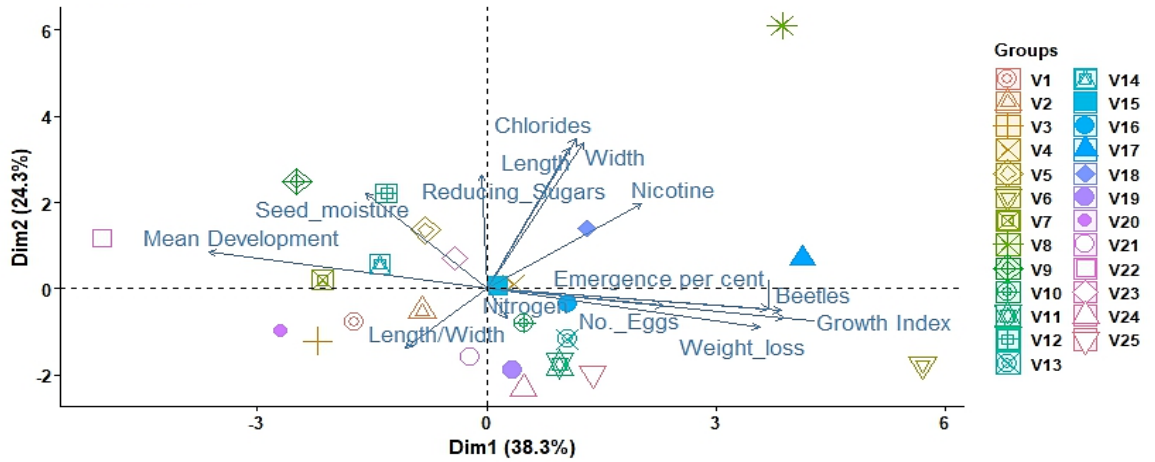

Fig 4. PCA biplot of the contribution of various factors for varietal susceptibility [V1 (A119); V2 (Abirami); V3 (Banket A1); V4 (CTRI Naveena); V5 (CTRI Sreshta); V6 (CTRI Sulakshana); V7 (CTRI Vijetha); V8 (DCT-4); V9 (Dharla); V10 (FCH 222); V11 (GABT11); V12 (Gajapati); V13 (GCT-3); V14 (GT-7); V15 (HDBRG); V16 (I737); V17 (Izmir); V18 (Kurnool Natu); V19 (Lanka Special); V20 (Nandyala Pogaku-1); V21 (Nandyala Pogaku-2); V22 (Podali); V23 (Siri); V24 (Vedaganga-1) and V25 (Yasini)]

L. serricorne has considerable damage potential because of its adaptability to a wide host range and its flight capacity. However, the insect can develop better on certain foods, indicating the vulnerability of a commodity. This creates scope for using a particularly

favourable commodity to trap the storage pest. Here, Izmir (oriental type) and CTRI Sulakshana (FCV tobacco) were found to be more suitable for *L. serricorne* in terms of growth index and weight loss of the seed (14.53–14.57%).

Studies focusing exclusively on tobacco seed suitability for *L. serricorne* are scarce in the published literature. This study may be among the first reports on cigarette beetle infestation and the suitability of tobacco seed. The susceptibility to *L. serricorne* is driven by multiple factors, which could be further evaluated with free-choice tests to investigate host selection.

4. Conclusions

The packaged food, tobacco, and other high-value spice industries experience substantial damage from the cigarette beetle *L. serricorne*. This study reports on host suitability and developmental biology of *L. serricorne* on tobacco seed. As some seeds have undetectable nicotine levels and contain sugars, *L. serricorne* may develop successfully on tobacco seed. These findings may help focus monitoring efforts on susceptible tobacco seed lots and protect valuable seed stocks.

CTRI Sulakshana and Izmir were the most susceptible among the varieties evaluated for *L. serricorne* with high emergence, high growth indices, and high weight loss. They also had the shortest developmental periods. Varieties showing relatively lower susceptibility were Podali, Dharla and Banket A1 based on the weight-loss parameter. No single biochemical or physical trait explained infestation severity, as indicated by the correlation analysis and PCA. However, the no-choice test required the insects to feed on the seeds provided. Further free-choice tests are needed to identify the most susceptible varieties and guide priorities for safe storage, fumigation, packaging, and sale.

5. Limitations

The study used a laboratory no-choice assay, so the results describe beetle performance on the seeds provided rather than preference when alternative varieties are available. Conditions were maintained at 30 ± 2 °C and 70 ± 2% relative humidity, limiting direct extrapolation to other storage environments. The reported correlations and principal component analysis identify associations but do not establish causal effects of individual seed traits. Free-choice tests and evaluations under additional storage conditions are needed to assess whether the observed varietal rankings remain consistent.

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Declaration of AI Use

This manuscript was prepared through the intellectual contributions of the author(s) to the study design, data analysis, interpretation of results, and scholarly content. ChatGPT, Claude and Perplexity were used solely to assist with grammatical refinement and reference formatting during manuscript revision. The author(s) accept full responsibility for the accuracy, integrity, and final content of the manuscript.

Competing Interests

Authors have declared that no competing interests exist.

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