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RESEARCH ARTICLE

In-vitro assessment of host suitability of thirty-one bamboo species to the invasive polyphagous pest *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae)

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Abstract: The fall armyworm (*Spodoptera frugiperda*) which is a highly invasive and polyphagous pest native to the Americas, has rapidly expanded its range, establishing itself across Asia, including India since 2018. Its arrival creates a serious biosecurity threat, not only to agricultural crops but also to non-traditional hosts such as forest and plantation species. Bamboos are critical to India's forestry economy and ecosystem functions, and remain largely unexplored as potential hosts. In this study, we conducted an in-vitro host suitability assessment of *S. frugiperda* across thirty-one commercially viable bamboo species using *Ricinus communis* as a positive control. Our results identified *Dendrocalamus latiflorus*, *D. stocksii* (*Pseudo xytenanthera stocksii*), *Thyrsostachys oliveri* and *T. siamensis* as highly susceptible to larval feeding, indicating their vulnerability in open or plantation settings. In contrast, species such as *D. strictus*, *P. madhavii*, *Ochlandra travancorica*, *Bambusa pallida*, *D. longispathus*, *O. ebracteata*, and *Schizostachyum brachycladum* demonstrated strong resistance with minimal feeding. A network diagram constructed from the feeding response data visually delineates clusters of susceptible and resistant species, highlighting potential candidates for pest-resilient bamboo cultivation. Given the ecological and economic importance of bamboo in India, these findings underscore the urgent need to integrate pest risk assessment into bamboo agroforestry planning and breeding programs. This study serves as a first step toward understanding the host range expansion potential of *S. frugiperda* in various silviculture systems and provides valuable insights for future pest management and policy strategies concerning invasive pests in forestry plant species.

Keywords: fall-armyworm, host range, invasive insect, bamboo cultivation, pest risk assessment

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Introduction

The global movement of pests and pathogens, accelerated by climate change, international trade, and monoculture expansion, continues to pose major challenges to forest health and agricultural sustainability. Sucking and chewing pests are the common insect threats challenging the stability of various ecosystems (Krishnan *et al.*, 2016, 2020). *Spodoptera litura* (Fabricius) an indigenous pest is one among the serious polyphagous pests in horticultural system (Harish and Krishnan, 2023). The fall armyworm, *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera:

Noctuidae), is one of the most notorious recent invasive pests. Native to the Americas and highly polyphagous, its introduction could cause severe crop damage and lead to significant ecological changes. The pest was initially detected in West Africa in 2016 and subsequently spread rapidly across the African continent, reaching Asia and Australia, with its presence confirmed in India by 2018 (Sharanabasappa *et al.,* 2018). In India, its first occurrence was documented on maize fields in Karnataka, and since then, it has been observed feeding on more than 80 plant species, including cereals, millets, vegetables, and fodder crops (Ganiger *et al.*, 2018; CABI, 2023). Though the pest's economic damage to maize and sorghum has been extensively studied, its broader host range potential, particularly in forestry systems, remains underexplored. *S. frugiperda* is a foliar feeder with high dispersal capabilities, high fecundity, and a flexible feeding mechanism that enables it to utilize a wide variety of host plants (Montezano *et al.*, 2018). These traits make it a serious threat not only to food crops but also to ecologically and economically significant non-crop species. The risk to forestry species warrants detailed host-range assessments to determine potential vulnerabilities (Goergen *et al.*, 2016) (Fig. 1).

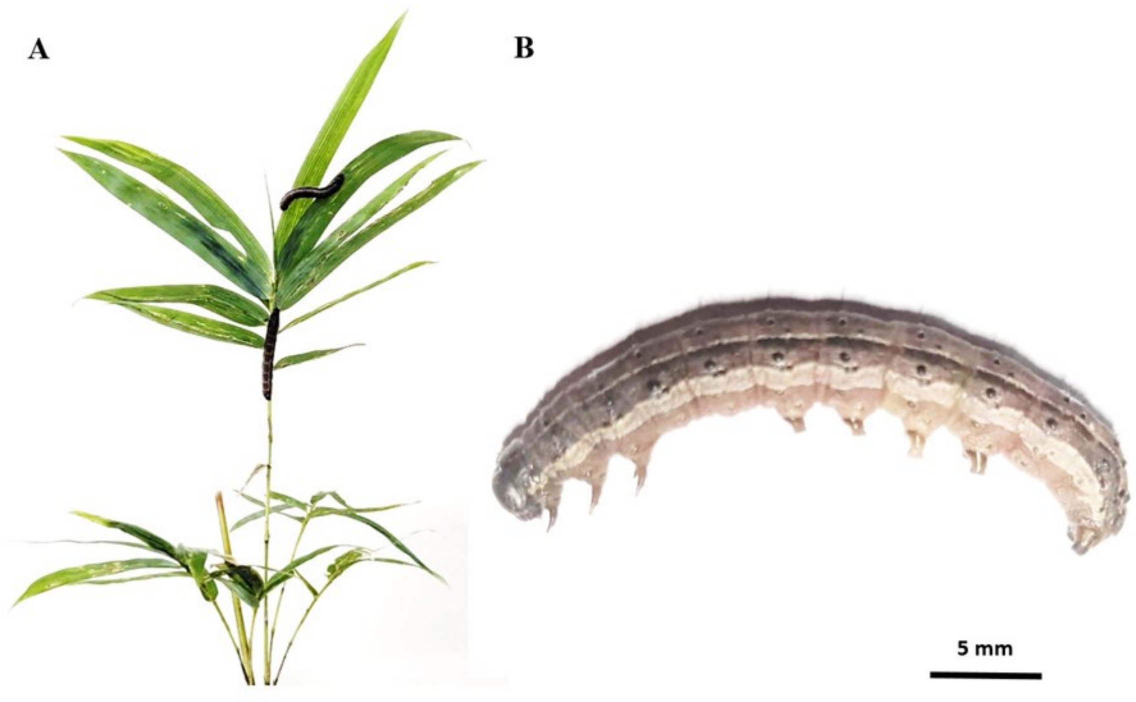

Fig 1. *Spodoptera frugiperda*; Fourth instar larvae infesting on the *Bamboosa polymorpha* in controlled condition inside the insectarium facility of KFRI (A); Fourth instar larvae in close-up image (B).

Bamboo is extensively cultivated as a commercial species in India and also occurs as monoculture stands in many of the natural forest regions. India holds a prominent place in global bamboo biodiversity, with more than 136 species across 23 genera, many of which are endemic to the Western Ghats and north-eastern regions (Sharma *et al.*, 2015; FSIR, 2023). Bamboo is not only an essential resource for rural livelihoods, paper and pulp industries, and emerging green construction markets, but also plays a critical ecological role in erosion control, carbon sequestration, and wildlife habitat formation. With recent national and state-level initiatives promoting bamboo cultivation for economic upliftment and sustainable forestry (NBM, 2022), the emergence of *S. frugiperda* as a potential pest on bamboo demands immediate attention and prevention. Despite this significance, empirical data on the pest-host interactions between

S. frugiperda and bamboo species are less. Anecdotal reports and field observations in parts of southern India have raised suspicions of larvae feeding on young bamboo shoots and leaves in nurseries and plantations, but systematic studies are lacking. The current study seeks to fill this gap by assessing the in-vitro host suitability of *S. frugiperda* across 31 commercially important bamboo species, using *Ricinus communis* as a positive control.

The study provides a controlled environment to assess feeding preferences, developmental compatibility, and potential for pest establishment across host plants. The experiment objectivizes pest risk analysis (PRA), particularly for non-traditional hosts that may not yet show overt signs of infestation in field conditions (Dias *et al.*, 2016). Given that *S. frugiperda* larvae exhibit considerable plasticity in diet selection under nutritional stress or when preferred hosts are unavailable (Montezano *et al.*, 2018), it is plausible that bamboo species could serve as alternative or secondary hosts in pest-colonized landscapes.

In our study, thirty-one bamboo species encompassed major genera such as Bambusa, Dendrocalamus, Gigantochloa, Schizostachyum, Ochlandra, Pseudoxytenanthera, Oxytenanthera, and Thyrsostachys were selected based on their commercial relevance, ecological distribution, and prevalence in plantations or natural stands. The choice of *Ricinus communis* as a positive control was informed by its established status as a susceptible host in *S. frugiperda* host preference studies (CABI, 2023). Qualitative observations were made on larval feeding behavior, and leaf damage patterns under standardized laboratory conditions. This study is relevant as it identifies bamboo species vulnerable or resistant to the invasive pest *S. frugiperda*, which poses an emerging threat to India's bamboo-based forestry and agroforestry sectors. The findings provide critical insights for PRA and species selection in commercial bamboo cultivation.

Materials and methods

The study was conducted using fresh bamboo leaves collected from the Field Research Centre (FRC) of the Kerala Forest Research Institute (KFRI), Palapilly, and the KFRI Bamboo Nursery, Peechi. A total of thirty-two test samples including two variants of *Bambusa vulgaris*, and one positive control (*Ricinus communis*) were used (Table 1). All experiments were conducted using fresh leaves, with uniform segments (10 g per replicate) cut with straight margins to facilitate identification of larval biting and feeding marks.

Table 1: List of plants employed in the susceptibility testing on *Spodoptera frugiperda*.

Sl. No.	Species
	Bamboo species
1	*Bambusa balcooa* Roxb.
2	*Bambusa bambos* (L.) Voss
3	*Bambusa dissimulator* Mc Clure
4	*Bambusa multiplex* (Lour.) Raeusch. ex Schult.f.
5	*Bambusa pallida* Munro
6	*Bambusa polymorpha* Munro
7	*Bambusa tulda* Roxb.
8	*Bambusa vulgaris* Schrad. ex J.C.Wendl. (Green) *Bambusa vulgaris* (Yellow)
9	*Dendrocalamus asper* (Schult & Schult f.) Backer ex Heyne
10	*Dendrocalamus giganteus* Munro
11	*Dendrocalamus hamiltonii* Nees & Arn. ex Munro
12	*Dendrocalamus latiflorus* Munro.
13	*Dendrocalamus longispathus* (Kurz) Kurz

14	*Dendrocalamus membranaceus* Munro
15	*Dendrocalamus sikkimensis* Gamble ex Oliver
16	*Dendrocalamus stocksii* (Munro) M.Kumar, Remesh & Unnikrishnan (=*Pseudoxytenanthera stocksii* (Munro) T.Q.Nguyen)
17	*Dendrocalamus strictus* (Roxb.) Nees
18	*Gigantochloa atroviolacea* Widjaja
19	*Gigantochloa manggong* Widjaja
20	*Gigantochloa rostrata* K. M. Wong
21	*Melocanna baccifera* (Roxb.) Kurz
22	*Ochlandra ebracteata* Raizada & Chatterji
23	*Ochlandra travancorica* (Bedd.) Gamble
24	*Ochlandra wightii* (Munro) C.E.C.Fisch.
25	*Oxytenanthera bourdillonii* (Gamble) H.B.Naithani
26	*Pseudoxytenanthera madhavii* P.Tetali, Datar, S.Tetali, E.Mural. & R.K.Choudhary
27	*Pseudoxytenanthera ritchiei* (Munro) H.B.Naithani
28	*Schizostachyum brachycladum* (Kurz ex Munro) Kurz
29	*Schizostachyum pergracile* (Munro) R.B.Majumdar
30	*Thyrsostachys oliveri* Gamble
31	*Thyrsostachys siamensis* Gamble
	Non-bamboo species
32	*Ricinus communis* L. (Positive Control)

Third instar (L3) larvae of *Spodoptera frugiperda* used in the study were obtained from a laboratory culture maintained at the KFRI Insectarium (Fig 2). The original egg batch was procured from the National Bureau of Agricultural Insect Resources (NBAIR), Bangalore, with an egg-laying date of 5th June 2025. Larvae were reared on *R. communis* leaves in 500 ml plastic containers, each with adequate ventilation and humidity maintained using silica crystals. A maximum of ten larvae were maintained per container, and fresh leaves were supplied every two days following removal of frass and debris. All the frass and debris were kept in boiling water to assure no insect where escaping from the study system to the open environment.

For the experiment, individual L3 larvae were introduced into 50 ml capacity units as either culture bottles or multi-unit trays, each containing a 7 g bamboo leaf sample (Fig 1). Three replicates were maintained for each test species and for the positive control. The experimental units were held in the KFRI Insectarium under standard conditions, and larval feeding was allowed for 12 hours. Post-exposure, the leaves were examined for feeding damage, and scores were assigned based on a 5-point scale: 0 = no feeding; 1 = <10% feeding; 2 = 10–<30% feeding; 3 = 30–<50% feeding; 4 = 50–<80% feeding; and 5 = 80–100% feeding.

Data analysis: Mean rating of bamboo species susceptible to *Spodoptera frugiperda*: Raw data were analysed using Python 3.13.5; we had calculated standard error for mean ratings; created a bar plot for mean ratings of bamboo species; added error bars to represent standard error; included a vertical line for positive control; and displayed the plot with adjusted layout.

Visualized the variance for each bamboo species by creating a bar plot was also worked out using Python 3.13.5.

Created a network diagram of bamboo species based on their susceptibility to *S. frugiperda*, highlighting connections based on mean ratings in a graph object and by adding bamboo species as nodes with distinct colors using the RStudio 2023.06.2. Added *Ricinus communis* as a distinct node. Established edges between nodes based on a mean rating threshold. Visualized the network with a spring layout and highlighted specific nodes.

Results

The in-vitro assessment of 31 commercially viable bamboo species against the fall armyworm, *Spodoptera frugiperda*, revealed varying levels of host suitability, identifying both highly susceptible and potentially resistant species. *Ricinus communis* served as a positive control, establishing a benchmark for high susceptibility, as it is an established susceptible host. Our results indicated that *Dendrocalamus latiflorus*, *D. stocksii*, *Thyrsostachys oliveri*, and *T. siamensis* were highly susceptible to larval feeding, signifying their potential vulnerability in open or plantation settings. In contrast, species such as *D. strictus, Pseudo xytenanthera madhavii, Ochlandra travancorica, Bambusa pallida, D. longispathus, O. ebracteata,* and *Schizostachyum brachycladum* demonstrated feeding resistance.

Fig 2. Culturing and experimental set-up maintaining *Spodoptera frugiperda* in the insectarium facility of KFRI | A: Maintaining the different instars of *S. frugiperda* larvae up to the stage of instar three (298 nos.) in 500 ml bottles with *Ricinus communis* as feed. | B: Rectangular culture tray with square units (50ml each) used for the feeding experiment. | C: 50 ml plastic bottles used for the feeding experiment.

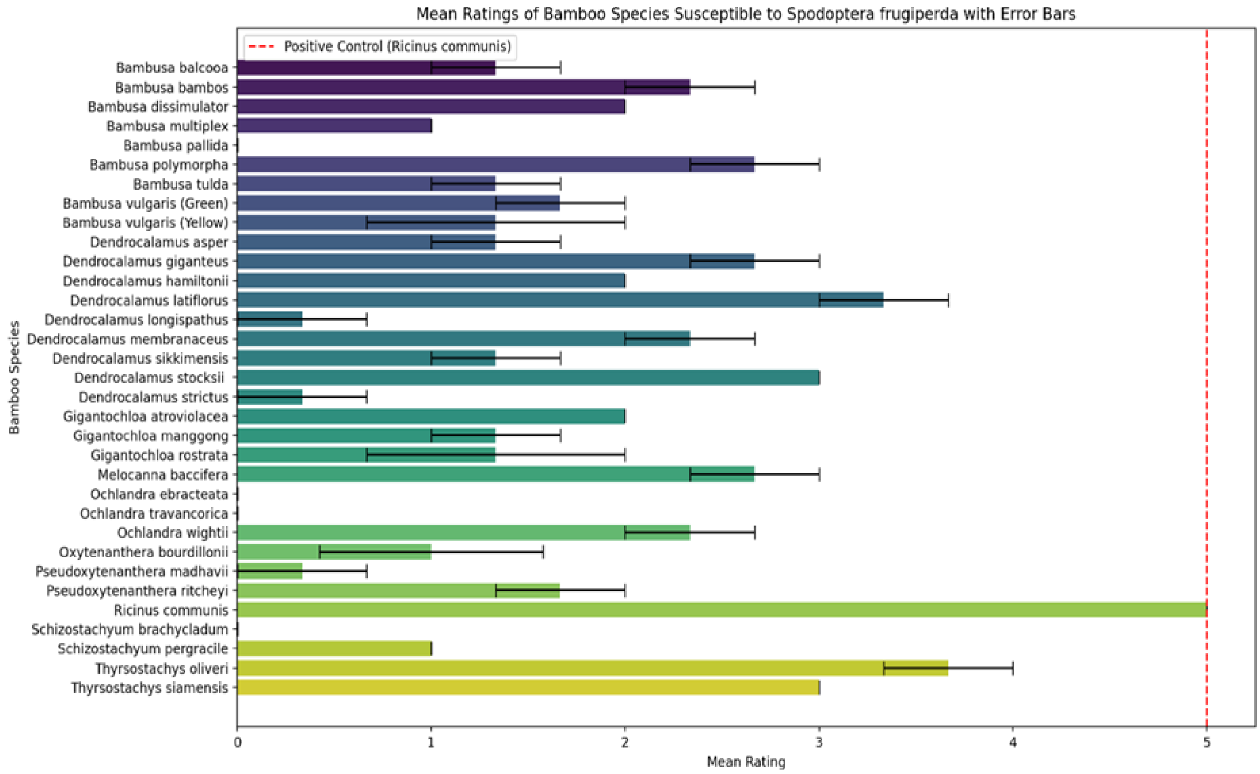

Fig 3. Mean rating of bamboo species susceptible to *Spodoptera frugiperda* with standard error bars.

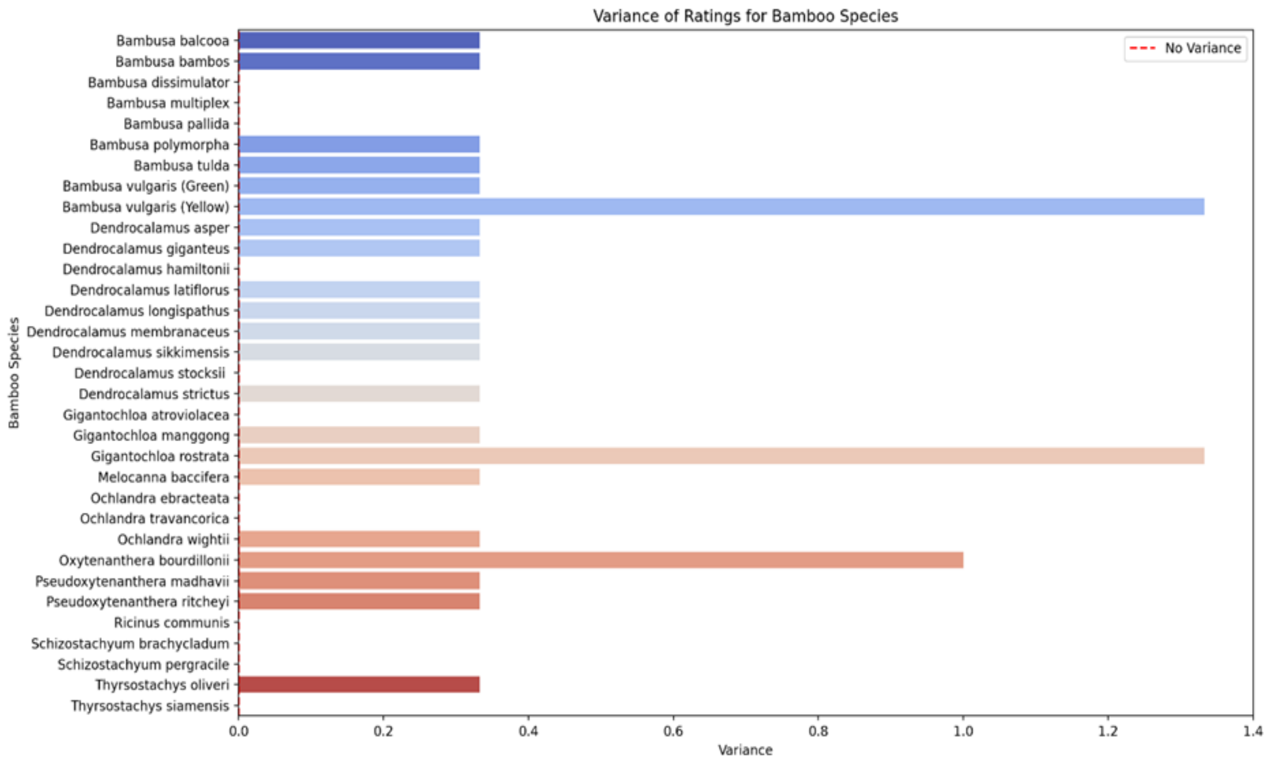

Fig 4. Variance bar diagram indicating the consistency and variability of the feeding response of *Spodoptera frugiperda*.

Fig. 3 indicates the mean feeding ratings for each bamboo species with standard error. The plot places a vertical line at a rating of 5, indicating the positive control's (*Ricinus communis*) maximum susceptibility level.

A bar plot (Fig 4) was utilized to visualize the variance of ratings for each bamboo species, illustrating the consistency or variability of the feeding response. A network diagram was constructed from the feeding response data (Fig 5); the diagram visually delineates clusters of susceptible and resistant species, highlighting connections between species based on a mean rating threshold. The network diagram includes the bamboo species as nodes with distinct colors for clusters and *R. communis* as a separate node, representing their relationships and host suitability.

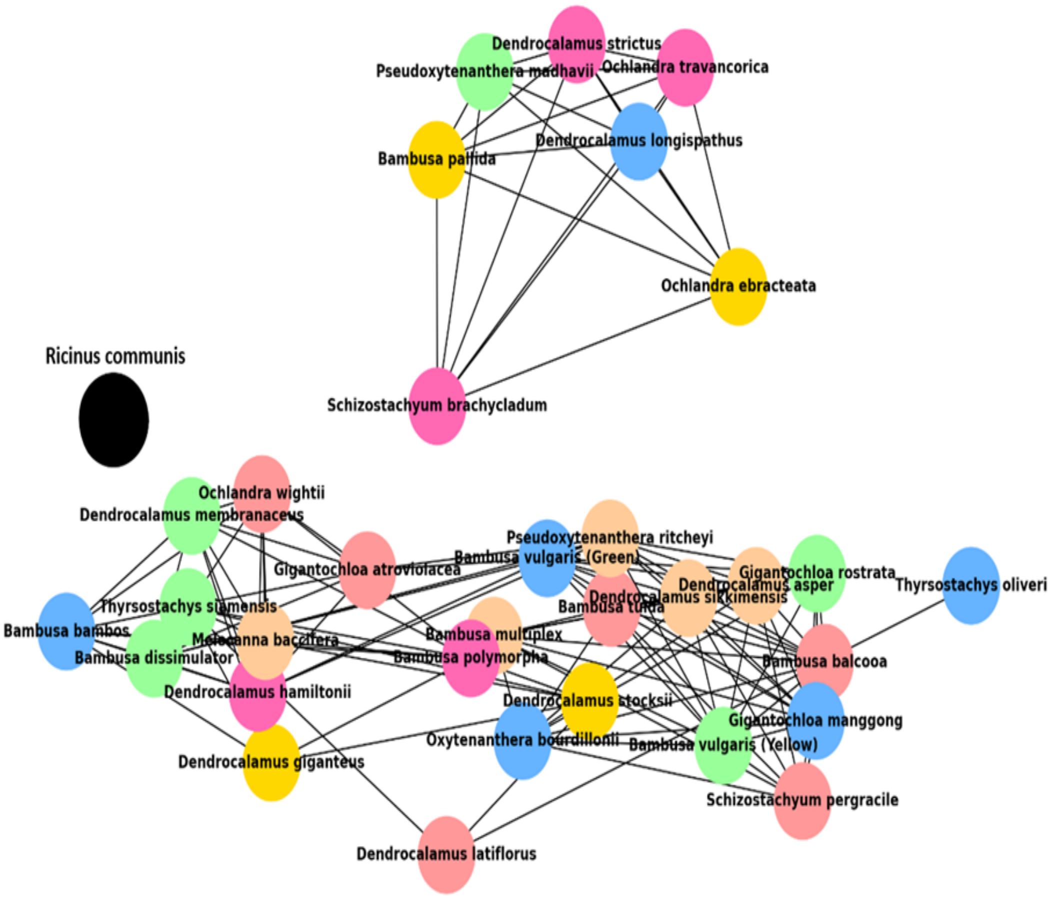

Fig 5. A network diagram delineating the susceptible and the potentially resistant species.

Discussion

The feeding trials revealed a distinct gradient of host suitability among the 31 bamboo species tested, reflecting interspecific variation in the response of *Spodoptera frugiperda* L3 larvae. The highest feeding ratings recorded on *Dendrocalamus latiflorus*, *D. stocksii*, *Thyrsostachys oliveri*, and *T. siamensis* clearly indicate their high palatability and nutritional compatibility with the larvae under in-vitro conditions. These species showed consistent larval engagement with rapid initiation of feeding and substantial foliar damage within the 12-hour exposure period, suggesting that they may support complete larval development, if encountered under field conditions.

This aligns with the broader understanding that *S. frugiperda* shows a strong preference for soft-leaved monocotyledons, especially members of Poaceae with high nitrogen content and moderate leaf toughness (Chen and Buntin, 2009; Braman *et al.*, 2002).

In contrast, a group of species including *Dendrocalamus strictus, Bambusa pallida, D. longispathus, Ochlandra travancorica, O. ebracteata, Pseudoxytenanthera madhavii*, and *Schizostachyum brachycladum* exhibited minimal to negligible feeding. Larvae often avoided these leaves or engaged only in marginal biting, and damage did not exceed a score of 1 in most replicates. This suggests possible antixenosis (non-preference) or antibiosis (adverse nutritional/ chemical properties), as observed in other host resistance studies on lepidopteran pests (Pamidi *et al.*, 2025). The physical characteristics of these bamboo species such as tougher leaves, higher fiber content, or defensive compounds could influence larval deterrence or impaired digestion.

The network diagram effectively visualized these distinctions, separating susceptible and resistant species into discrete clusters based on feeding scores. Interestingly, some members of the same genus showed divergent responses; e.g., *D. latiflorus* (highly susceptible) *vs D. strictus* (resistant) pointing toward intra-generic variability, likely shaped by structural or phytochemical differences, a trend also reported in cereal host evaluations for the same pest (Dos *et al.*, 2020). The variance plot further reinforced the consistency of larval response in resistant species, where standard error margins were narrow, while susceptible species showed moderate variation. This consistency in resistance ratings supports the reliability of such species as candidates for pest-resilient plantations or further resistance breeding, as noted by Huayu *et al.* (2023).

Conclusion

India continues to expand its bamboo economy under the National Bamboo Mission and through various programmes of Forest Department. This largely demand integrating pest risk studies into plantation planning. The possibility that *S. frugiperda* may switch hosts under environmental pressure or due to pesticide pressure from agroforestry settings, cannot be dismissed. Further, the pest's potential movement from agricultural to forested landscapes presents an emerging threat to the ecological balance of forest fringes and buffer zones of protected areas. The current study provides a foundational understanding of the interaction between *S. frugiperda* and a broad spectrum of bamboo species under controlled conditions. The results not only offer practical insights into pest-resistant species selection but also serve as a baseline for future studies on pest dynamics in forestry systems. Ongoing monitoring, field validation, and biochemical profiling of resistant species will be necessary to fully elucidate the mechanisms behind host suitability and resistance.

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Authors contribution

JUK: Conceived the study, designed the methodology, data curation, prepared the first draft, and correspondence; PK: verified the methodology, bamboo species identity, preparation of manuscript; SVB: verified the methodology, bamboo species identity, preparation of manuscript; SNGK: maintenance of the insect, data visualization, preparation of the manuscript; BM: bamboo species identity, preparation of manuscript.

References

Braman, S.K., Duncan, R.R., Engelke, M.C., Hanna, W.W., Hignight, K. and Rush, D., 2002. Grass species and endophyte effects on survival and development of fall armyworm (Lepidoptera: Noctuidae). *Journal of economic entomology*, *95*(2), pp.487-492. https://doi.org/10.1603/0022-0493-95.2.487

CABI. 2023. *Spodoptera frugiperda* (fall armyworm) datasheet. In: Invasive Species Compendium. [https://www.cabi.org/isc]

Chen, Y., Ni, X. and Buntin, G.D. 2009. Physiological, nutritional, and biochemical bases of corn resistance to foliage-feeding fall armyworm. *Journal of chemical ecology*, *35*, pp.297-306. https://doi.org/10.1007/s10886-009-9600-1.

Dias, A.S., Marucci, R.C., Mendes, S.M., Moreira, S.G., Araujo, O.G., dos SANTOS, C.A. and Barbosa, T.A. 2016. Bioecology of Spodoptera frugiperda (Smith, 1757) in different cover crops.

Dos Santos, L.F.C., Ruiz-Sánchez, E., Andueza-Noh, R.H., Garruña-Hernández, R., Latournerie-Moreno, L. and Mijangos-Cortés, J.O., 2020. Leaf damage by Spodoptera frugiperda JE Smith (Lepidoptera: Noctuidae) and its relation to leaf morphological traits in maize landraces and commercial cultivars. *Journal of Plant Diseases and Protection*, *127*, pp.103-109. https://doi.org/10.1007/s41348-01900276-y.

FSIR. 2023. *Forest Survey of India Report*. Ministry of Environment, Forest and Climate Change, Government of India.

Ganiger, P.C., Yeshwanth, H.M., Muralimohan, K., Vinay, N., Kumar, A.R.V., & Chandrashekara, K. (2018). Occurrence of the invasive fall armyworm, *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae), in maize in Karnataka, India. *Current Science*, 115(4), 621–623.

Goergen, G., Kumar, P.L., Sankung, S.B., Togola, A. and Tamò, M. 2016. First report of outbreaks of the fall armyworm Spodoptera frugiperda (JE Smith) (Lepidoptera, Noctuidae), a new alien invasive pest in West and Central Africa. *PloS one*, *11*(10), p.e0165632.

Govaerts, R. 2009. *World checklist of selected plant families*. Royal Botanic Gardens. [Cited as *Pseudoxytenanthera stocksii*.]

Harish, E.R. and Krishnan, J.U. 2023. Cost-effective media for mass production of Bacillus thuringiensis Berliner for the management of taro caterpillar, Spodoptera litura Fabricius. *J Entomol Res*, *47*(1), pp.8-15. DOI : 10.5958/0974-4576.2023.00002.6

Sun, H., Wang, J., Li, H., Li, T. and Gao, Z., 2023. Advancements and challenges in bamboo breeding for sustainable development. *Tree Physiology*, *43*(10), pp.1705-1717.https://doi.org/10.1093/treephys/tpad 086.

Krishnan, J.U., George, M., Ajesh, G., Jithine, J., Lekshmi, N.R. and Deepasree, M.I., 2016. A review on Paracoccus marginatus Williams, papaya mealybug (Hemiptera: Pseudococcidae). *Journal of entomology and Zoology Studies*, *4*(1), pp.528-533.

Krishnan, J.U., Jayaprakas, C.A., Harish, E.R. and Rajeswari, L.S. 2020. Banana (Musa spp.)-an unseen umbrella crop? Insect diversity on Musa spp. in the Indo-Pacific region. *Oriental Insects*, *54*(3), pp.433-445. https://doi.org/10.1080/00305316.2019.1667926

Montezano, D.G., Sosa-Gómez, D.R., Specht, A., Roque-Specht, V.F., Sousa-Silva, J.C., Paula-Moraes, S.D., Peterson, J.A. and Hunt, T.E. 2018. Host plants of Spodoptera frugiperda (Lepidoptera: Noctuidae) in the Americas. *African entomology*, *26*(2), pp.286-300. https://hdl.handle.net/10520/EJC-112bc26060

NBM. 2022. *National Bamboo Mission Progress Report*. Ministry of Agriculture and Farmers Welfare, Government of India.

Pamidi, L.S., Sekhar, J.C., Yathish, K.R., Karjagi, C.G., Rao, K.S., Suby, S.B. and Rakshit, S. 2025. Characterization of antixenosis and antibiosis resistance to the fall armyworm, Spodoptera frugiperda (JE Smith) in maize. *Phytoparasitica*, *53*(1), p.4. https://doi.org/10.1007/s12600-024-01228-5

Sharanabasappa, S., Kalleshwaraswamy, C.M., Asokan, R., Swamy, H.M., Maruthi, M.S., Pavithra, H.B., Kavita Hegde, K.H., Shivaray Navi, S.N., Prabhu, S.T. and Goergen, G. 2018. First report of the fall armyworm, Spodoptera frugiperda (JE Smith) (Lepidoptera: Noctuidae), an alien invasive pest on maize in India.

Sharma, M.L. and Nirmala, C., 2015, September. Bamboo diversity of India: an update. In *10th World Bamboo Congress, Korea* (pp. 17-22).