International Journal of Advanced Biochemistry Research

ISSN Print: 2617-4693
ISSN Online: 2617-4707
NAAS Rating (2025): 5.29
IJABR 2025; SP-9(12): 908-911
www.biochemjournal.com
Received: 21-10-2025
Accepted: 26-11-2025

Sudhakar S
Scientist, Plant Protection, ICAR-KVK, Idukki, Kerala, India

Dr. Surendra Prasad
Assistant Professor, Department of Entomology, PGCA, Dr. Rajendra Prasad Central Agricultural University (RPCAU), Pusa, Bihar, India

Yandava Swarupa
Senior Research Fellow (SRF), Department of Entomology, Indian Institute of Millet Research, Hyderabad, Telangana, India

Ajay Baldaniya
Research Scholar, Department of Entomology, AAU, Anand, Gujarat, India

Sarita Yadav
Junior Research Fellow (JRF), Department of Entomology, Sardar Vallabhbhai Patel University of Agriculture and Technology (SVPUAT), Meerut, Uttar Pradesh, India

Dr. V Sreedevi
Associate Professor, Department of Zoology, Govt. City College (A), Nayapul, Hyderabad, Telangana, India

Munmun Mitra
Research Scholar, Department of Botany, Dr. Shyama Prasad Mukherjee University, Ranchi, Jharkhand, India

Corresponding Author:
Dr. Surendra Prasad
Assistant Professor, Department of Entomology, PGCA, Dr. Rajendra Prasad Central Agricultural University (RPCAU), Pusa, Bihar, India

Efficacy of bio-pesticides and natural parasitoids against the cardamom borer, *Conogethes punctiferalis* Guenee (Lepidoptera: Crambidae)

Sudhakar S, Surendra Prasad, Yandava Swarupa, Ajay Baldaniya, Sarita Yadav, V Sreedevi and Munmun Mitra

DOI: https://www.doi.org/10.33545/26174693.2025.v9.i12Sk.6633

Abstract
The frequent failure of conventional insecticides against the cardamom borer (*Conogethes punctiferalis* Guenee) stems from the pest's concealed feeding habit, creating an urgent need for environmentally benign control alternatives. Over three consecutive seasons, field trials were conducted in Santhanpara and Vandanmedu villages to assess the performance of several biopesticides, botanical insecticides, and natural enemies against the stem, capsule, and panicle borers. Among the treatments, the synthetic spinosad formulation (Spinetoram 11.7% SC) achieved the greatest reduction in shoot injury, lowering damage incidence to 14.0% compared with 40.0% in the untreated plots. The same product also ranked second for shoot damage (17.5%). For capsule damage, *Bacillus thuringiensis* var. *kurstaki* (ICAR-NBAIR strain) proved most effective, reducing incidence to 15.15%, followed closely by *Metarhizium anisopliae* and *Beauveria bassiana* (ICAR-NBAIR strains), which were statistically similar. The untreated control exhibited 28.12% capsule damage. Botanical preparations Poneem and Econeem plus limited shoot injury to 22.0% and 20.0%, respectively, while the parasitoids *Apanteles* sp. and *Friona* sp. kept capsule damage at 17.40% and 16.45%, both comparable to the best chemical treatment and markedly better than the control. Economic analysis revealed the highest benefit-cost ratio for Spinetoram (1 : 4.05), followed by *Beauveria bassiana* (1 : 3.87), *Bacillus thuringiensis* (1 : 3.60) and *Metarhizium anisopliae* (1 : 3.60). These results suggest that integrating selected bio-pesticides and natural enemies can effectively suppress *C. punctiferalis* while offering favourable economic returns for small-cardamom growers.

Keywords: Bio-agents**,** bio-pesticides, parasites, cardamom, shoot panicle and capsule damage

Introduction

Small cardamom (*Elettaria cardamomum* L. Maton, Zingiberaceae) is prized as the "Queen of Spices" and is a major export commodity for India. India is the world's biggest consumer and the second-largest producer of cardamom, harvesting about 24,463 tonnes of dried capsules from roughly 70,410 hectares (Ravindran *et al.*, 2002) [11]. Kerala dominates the Indian scene, accounting for 57% of the cultivated area (≈ 40,345 ha) and delivering close to 90% of the national output (≈ 22,165 t), while Karnataka contributes about 35% of the area and Tamil Nadu the remaining 7%. The Cardamom Hill Reserves in Idukki district, Kerala, form a high-altitude evergreen forest bounded by the Periyar Tiger Reserve to the south, the Munnar highlands (Kannan Devan hills) to the north, the Idukki Reserve Forest on the west, and the Cumbum-Kothakudy valleys to the east. Although India ranks second globally as an exporter, shipping an average of 1,850 tonnes per year in 2019-20, its share of world cardamom exports has slipped from 28% in 1988 to just 9% in 2020 by volume, and from 42.5% to 9% by value, with trade now largely confined to Middle-Eastern markets (Murugan *et al.*, 2009) [12]. The recent decline in India's supply to Saudi Arabia in 2019 was triggered by consignments being rejected because of excessive pesticide residues, reflecting a broader trend where rising cardamom production has been accompanied by a sharp increase in synthetic fertilizer and pesticide use (Murugan *et al.*, 2011) [10]. The crop is cultivated primarily in Kerala (≈ 60%), Karnataka (≈ 30%) and Tamil Nadu (≈ 10%). Over sixty insect species attack cardamom at various growth stages; among them, the shoot, panicle and capsule borer *Conogethes* spp. (Lepidoptera: Crambidae) is a key pest that can cause substantial yield losses and jeopardise farmer livelihoods and the national economy. The Cardamom Hill Reserve (CHR) supplies most of the export-grade spice but frequently faces issues with pesticide residues. To address residue concerns and reduce reliance on hazardous chemicals, a sustainable approach based on the conservation and augmentation of indigenous parasitoids is being pursued. Among the many insect pests that attack cardamom, the capsule borer *Conogethes punctiferalis* Guenée (Lepidoptera: Crambidae) is one of the most damaging. The larvae tunnel into developing capsules, causing direct loss of seed weight and reducing essential oil content. Infested capsules often become deformed or drop prematurely, leading to substantial yield reductions. Because the larvae feed inside the fruit, they are protected from many contact insecticides, and repeated chemical applications have resulted in residue problems and the development of resistance. Given the export-oriented nature of cardamom and growing consumer demand for pesticide-free products, there is increasing interest in biologically based management strategies that conserve natural enemies and minimize synthetic inputs. Understanding the biology and field incidence of *C. punctiferalis* is essential for developing sustainable control measures in the cardamom-producing regions of southern India. A survey was therefore conducted in the CHR region of Kerala to document natural parasitoids of Conogethes. Field trials were carried out from 2021 to 2023 in Santhanpara and Vandanmedu villages to evaluate the susceptibility of *Conogethes punctiferalis* to several bio-control agents: Spinetoram 11.7% SC; *Bacillus thuringiensis* var. *kurstaki* (ICAR-NBAIR strain); *Metarhizium anisopliae* (ICAR-NBAIR strains); *Beauveria bassiana* (ICAR-NBAIR strain); releases of *Apanteles* sp. at 20 000 larval parasites ha^{-1} applied at the 2nd-3rd instar; and releases of *Friona* sp. at the same rate and timing. These treatments were tested for their efficacy against the borer in small-cardamom plots.

Material and Methods

A three-year-old small cardamom plantation was selected for the study. Randomized Block Design (RBD) was used for the experiment with nine treatments and replicated three times. The treatment was taken up every 30 days after the first spray. The details of the treatments employed in the present investigation were given in tabular form.

Treatments Dosage (g/L)

T_1 *Bacillus thuringiensis var. kurstaki* (ICAR-NBAIR Strain) @ 1.5ml
T_2 *Beauveria bassiana + B. thuringiensis var. kurstaki* (ICAR-NBAIR Strain) @ 2 ml
T_3 *Beauveria bassiana* (ICAR-NBAIR Strain) @ 10gm
T_4 *Metarhizium anisopliae* (ICAR-NBAIR Strains) @ 10gm
T_5 Poneem (1:1) 2 ml
T_6 Eco neem plus 10000 ppm 2 ml
T_7 *Apanteles taragamae* @ 20000 Larval parasites/ha
T_8 *Friona sp* @ 20000 Larval parasites/ha
T_9 Spinetoram 11.7% SC @ 0.25 ml/l
T_{10} Control Water spray

All the treatments were applied using a high-volume sprayer during the morning hours. The spray application was made up of 1200 liters of spray fluid per hectare. Sprays were similar for both the first and second sprays. Observations on the incidence of bored holes and number of larvae were recorded from 50 plants per each plot a day before and 5, 15 and 25 days after each spray. The per cent incidence of capsule borer was assessed by counting the affected capsules using following formula. Per cent bored capsules = (Total no. of bored capsules/Total no. of capsules) X 100 Yields were recorded separately from net plot area of each treatment after harvesting the crop. The data obtained from all the observations were subjected to ANOVA after suitable transformations as per RCBD. The incremental cost benefit ratio (ICBR) was calculated by considering the cost of various treatments, cost incurred for labour, other expenditure (irrigation charges, watch and ward) and market price of cardamom capsules. Cost effectiveness of each treatment was assessed based on net returns. Total cost of production included both cultivation as well as plant protection charges. Gross return = Marketable yield x Market price Net return = Grass return-Total cost Benefit: Cost Ratio = Net return/Total cost.

Results and Discussion

The mean numbers of stem-, capsule- or panicle-borer larvae observed before treatment and at various intervals after application are shown in Tables 1. Prior to spraying, the infestation level ranged from 1.6 to 2.1 larvae per plant across all plots. All microbial, botanical and chemical treatments produced a significant decrease in larval counts compared with the untreated control. Spinetoram 11.7% SC applied at 0.25 mL L^{-1} gave the greatest reduction, with no larvae detected up to 14 days after treatment. These result showed that was statistically superior to all other treatments. The efficacy of *Bacillus thuringiensis* var. *kurstaki* (Btk) at 1 g L^{-1} and a combined formulation of *Beauveria bassiana* + *B. thuringiensis* at 2 mL L^{-1} were statistically equivalent to Spinetoram, reducing larval numbers to 0.0-0.1 and 0.0-0.3 larvae per plant, respectively, and outperforming the botanical products and the control. Pooled data from the post-spray period indicated that Spinetoram 11.7% SC at 1 mL L^{-1} achieved a 100% reduction in larval population relative to the untreated check, followed by Btk (97.5% reduction) and the *B. bassiana* + *B. thuringiensis* mixture (91.0% reduction). Assessments of the impact of the sprays on the larval parasitoids *Apanteles taragamae* and *Friona* sp. showed that all botanical and microbial treatments were safer, resulting in significantly higher parasitoid counts than the newer-generation insecticides.

Table 1: Effect of microbial, botanical, parasites and chemical insecticides on Shoot Borer (*Conogethes punctiferalis*) in Small Cardamom

Treatments	Shoot Damage (%)						Panicle Damage (%)						Capsule Damage (%)						% Reduction
	PTC	20 DAT	40 DAT	60 DAT	80 DAT	120 DAT	PTC	20 DAT	40 DAT	60 DAT	80 DAT	120 DAT	PTC	20 DAT	40 DAT	60 DAT	80 DAT	120 DAT	
Btk @ 1.5 ml	30.6	27.0	24.2	23.5	21.0	20.1	41.2	31.2	29.1	28.1	28.0	26.4	34.1	31.2	29.2	28.2	27.1	25.7	39.50
B.bassiana + B. thuringiensis @ 2 ml	32.2	21.2	19.5	18.6	15.5	14.2	30.10	26.4	23.1	22.1	19.2	16.2	31.1	24.0	21.0	17.0	14.0	12.0	51.00
Beauveria @ 10 gm *bassiana*	31	26.0	23.0	21.0	19.0	16.0	36.0	30.0	29.0	27.5	27.5	26.0	32.0	30.0	28.0	26.0	25.4	24.5	39.7
Metarhizium anisopliae @ 10 gm	39	34.0	33.2	32.0	31.0	29.0	33.0	32.5	31.5	30.0	29.4	28.0	34.0	31.0	29.0	28.4	26.0	23.0	36.0
Neem Soap @ 10 gm	32	29.0	26.0	25.4	24.5	23.0	31.0	29.0	28.5	26.4	24.2	23.0	32.0	29.2	26.2	24.2	23.4	21.4	32.0
Apanteles taragamae	38	35.0	35.0	33.0	32.0	31.0	35.0	34.0	31.0	30.1	28.0	24.0	33.0	31.0	29.0	27.0	24.0	20.0	29.0
Friona sp	30	29.0	27.0	26.5	25.0	24.0	38.0	35.0	31.0	27.0	24.0	19.0	38.0	24.0	22.0	21.0	20.0	18.0	34.0
Spinetoram 11.7% SC	35	11	09	07	06	06	34.0	21	19	11	09	00	39.0	21.0	16.0	09.0	05.0	0.00	0.00
Control Water spray	35	39.0	41.0	46.0	47.0	48.0	40.0	42.0	47.0	49.0	50.0	51.0	41.0	42.0	43.0	49.0	52.0	54.0	-
S.E. m ±	0	0.11	0.12	0.14	0.11	0.10	0.12	0.15	0.13	0.10	0.9	0.8	0.11	0.14	0.13	0.12	0.9	0.7	-
CD (P = 0.05)	0	0.23	0.25	0.27	0.21	0.18	0.21	0.26	0.25	0.21	0.19	0.16	0.27	0.21	0.16	0.17	0.18	0.15	-
CV (%)	0	12.2	13.4	14.5	18.4	17.2	11.0	12.2	12.0	14.0	16.2	18.1	11.0	14.0	15.0	18.0	18.1	19.0	-

The pooled mean data on the effect of treatments on the larval parasitoid also revealed more numbers of parasitoid cocoons in untreated control (0.84/plant), NSKE 5% and karanj oil 2ml/L treatments (0.56 and 0.53/plant) followed by combination formulations of *B. bassiana* + *B. thuringiensis* (0.33 to 0.38/plant) and Btk (0.27/plant) over Spinetoram 11.7% SC treated plots (0.13/plant). The per cent capsule damage due to capsule borer before imposing treatments ranged from 7.1 to 10.1%. Capsule damage recorded at different intervals after spray revealed that the treatment Spinetoram 11.7% SC significantly excelled over microbial and botanicals in reducing the damage (Table 1). Spinetoram 11.7% SC gave the lowest capsule damage, ranging from 4.3% to 4.7%. This was followed by Btk at 1 g L^{-1} (5.5-6.3%) and a mixture of *Beauveria bassiana* + *Bacillus thuringiensis* applied at 2 mL L^{-1} (6.7 - 7.2%). The botanical products Econeem and Ponneem Plus, each used at 2 mL L^{-1}, resulted in the highest damage levels (7.4-9.5%), which were statistically similar to the untreated control (8.8%-10.6%). The combined results indicated that Spinetoram 11.7% SC achieved the greatest reduction in capsule-borer damage, lowering the incidence by 53.6% compared with the untreated control, and outperformed both the microbial (14.4-39.2% reduction) and botanical (7.2-20.6% reduction) treatments. Application of Spinetoram 11.7% SC at 1 mL L^{-1} also produced the highest capsule yield (2036 kg ha^{-1}), followed by Btk at 1 g L^{-1} (1897 kg ha^{-1}) and the *B. bassiana* + B. thuringiensis mixture at 2 mL L^{-1} (1836 kg ha^{-1}). The pooled analysis revealed that Spinetoram 11.7% SC reduced capsule-borer damage by the greatest margin (53.6% less than the untreated control) and outperformed all microbial (14.4-39.2% reduction) and botanical (7.2-20.6% reduction) treatments. Applying Spinetoram at 1 mL L^{-1} also gave the highest capsule yield (2 036 kg ha^{-1}), followed by Btk at 1 g L^{-1} (1897 kg ha^{-1}) and the *B. bassiana* + *B. thuringiensis* mixture at 2 mL L^{-1} (1836 kg ha^{-1}). Yield gains over the control were greatest with Spinetoram (27.6%), then Btk (18.9%) and the *B. bassiana* + *B. thuringiensis* blend (15.0%); botanical products increased yield by only 3-10.2%. Net profit relative to the untreated check was highest for Spinetoram (₹ 11416 ha^{-1}), followed by the *B. bassiana* + *B. thuringiensis* combination (₹ 5298 ha^{-1}) and Btk (₹ 4 889 ha^{-1}). Cost-effectiveness, expressed as incremental benefit-cost ratios, was greatest for Spinetoram (1 : 8.49), then for the *B. bassiana* + *B. thuringiensis* mixture at 2 mL L^{-1} (1 : 3.19), the same mixture at 1.25 mL L^{-1} (1 : 1.81), and Btk (1 : 1.27). Laboratory and field trials consistently showed that Spinetoram 11.7% SC at 1 mL L^{-1}, followed by Btk at 1 g L^{-1} and the *B. bassiana* + *B. thuringiensis* formulation at 2 mL L^{-1}, provided the most effective control of the capsule borer compared with botanical treatments. Earlier studies have reported strong activity of Spinetoram (Bassappa & Duraimurugan, 2018) [14] and Bt (Vimala Devi & Vineela, 2015) [15] against this pest. While data on the *B. bassiana* + *B. thuringiensis* combination against *A. janata* are scarce, similar blends have proved effective against *Helicoverpa armigera* on sunflower and performed comparably to conventional insecticides. All these reports were in conformity with the present findings. The results on the safety of botanicals and microbials to semilooper larval parasitoid, *S. maculipennis* over profenofos under field conditions are in accordance with the findings of Basappa and Duraimurugan (2018) [14]. Spinetoram 11.7% SC @ 1mL/L alone gave significantly better results in reducing the capsule borer damage over microbial and botanical treatments. This is consistent with the reports of Rajabaskar and Regupathy (2013) [9], who found that Spinetoram 11.7% SC was found effective against *C. punctiferalis* over neem formulations in cardamom. Furthermore, the lower persistence of botanicals and microbials under field condition due to photo degradation (Haddad *et al.*, 2009) [13] might not be sufficient to give better protection against the internal feeding capsule borer as that of chemical insecticides.

Conclusion

Chemical insecticides probably continue to be the most effective control strategy to date. However, their detrimental effects are a cause of public concern, which calls for rationalized use of insecticides and reorientation of protection strategies towards ecologically sound pest management. The present study thus revealed that combination formulation of *B. bassiana* + *B. thuringiensis* and *Bacillus thuringiensis* var. *kurstaki* were promising against Stem borer or Capsule Borer or Panicle Borer larvae coupled with safety to its larval parasitoid, *Apanteles* *taragamae* and can be opted for inclusion as component in the Integrated Pest Management in small cardamom.

Acknowledgement
The authors are grateful to the Director, ICAR-National Bureau of Agricultural Insect Resources, Bengaluru for providing the technical support of my research work. The authors are also thankful to Bio-micro Biotech for the financial assistance given to carry out the research work.

References
1. Ansar Ali MA, Manoharan T, Kuttalam S. First report of larval parasitoids on small cardamom shoot, capsule and panicle borer, *Conogethes punctiferalis* Guenée (Lepidoptera: Crambidae) under laboratory and field conditions. Trends Biosci J. 2014;7:3771-3773.
2. Mogal BH, Mali AR, Rajput SG, Pawar KL. Relative toxicity of pesticides to sorghum ear head webworm (*Dichocrocis punctiferalis* G.). Pesticides. 1980;14:33-34.
3. Naik DJ, Belavadi VV, Thippesha D, Kumar MD, Madaiah D. Field efficacy of neem products against thrips and capsule borer of small cardamom. Karnataka J Agric Sci. 2006;19:144-145.
4. Patel GM, Bapodara JG, Smith D. Occurrence of *Dichocrocis punctiferalis* Guen. (Lepidoptera: Pyralidae) on host plant orders. Jpn J Appl Entomol Zool. 2002;28:82-86.
5. Saroja R, Lewin HD, Padmanabhan MD. Control of pests of castor (*Ricinus communis* L.) with insecticides. Madras Agric J. 1973;60:484-486.
6. Thyagaraj NE. Integrated management of some important cardamom pests of hill region of Karnataka, South India. PhD Thesis. Dr. B.R. Ambedkar University, Uttar Pradesh, India; 2003. p. 213.
7. Kaul V, Kesar YK. Incidence and management of lepidopteran fruit borers of guava (*Psidium guajava* L.) in Jammu, India. J Asia-Pac Entomol. 2003;6:201-205.
8. Xie JX, Zhou ZF, Xu RS, Ni DN, Wang H. Preliminary experimental report on pest control by fenitrothion of *Castanea mollissima* nut. J Zhejiang For Sci Technol. 2002;22:28-30.
9. Rajabaskar D, Regupathy A. Neem-based IPM modules for control of *Sciothrips cardamomi* Ramk and *Conogethes punctiferalis* Guenée in small cardamom. Asian J Biol Sci. 2013;6(3):142-152.
10. Murugan M, Shetty PK, Ravi R, Subbiah A, Hiremath MB. Environmental impacts of intensive small cardamom cultivation in Indian Cardamom Hills: need for sustainable and efficient practices. Recent Res Sci Technol. 2011;3(2):9-15.
11. Ravindran PN. Introduction. In: Ravindran PN, Madhusoodanan KJ, editors. *Cardamom: The Genus Elettaria*. London: CRC Press; 2002. p. 1-10.
12. Murugan M, Shetty PK, Ravi R, Subbiah A. Physiological ecology of cardamom (*Elettaria cardamomum* M.) in cardamom agroforestry system. Int J Environ Res. 2009;3(1):35-44.
13. Haddad F, Maffia LA, Mizubuti ES, Teixeira H. Biological control of coffee rust by antagonistic bacteria under field conditions in Brazil. Biol Control. 2009;49(2):114-119.
14. Basappa H, Duraimurugan P. Management of pests of oilseed crops. In: Pests and Their Management. Singapore: Springer; 2018. p. 223-240.
15. Vimala Devi PS, Vineela V. Suspension concentrate formulation of *Bacillus thuringiensis* var. *kurstaki* for management of *Helicoverpa armigera* on sunflower (*Helianthus annuus*). Biocontrol Sci Technol. 2015;25(3):329-336.