International Journal of Entomology Research
www.entomologyjournals.com
ISSN: 2455-4758
Received: 07-03-2026, Accepted: 07-04-2026, Published: 22-04-2026
Volume 11, Issue 2, 2026, Page No. 131-135

Impact of the leafhopper *Amrasca biguttula* on the growth and yield of cotton (*Gossypium hirsutum*) in northern Côte d'Ivoire

Adjoua Madeleine Kouassi[1], Drissa Coulibaly[2*], Jean-Baptiste Gnelie Gnahoua[1], Kolopima SORO[1], Yalamoussa TUO[2]
[1] Institute of Agropastoral Management (IGA), Peleforo Gon Coulibaly University, Korhogo, Côte d'Ivoire
[2] Faculty of Biological Sciences, Peleforo Gon Coulibaly University, Korhogo, Côte d'Ivoire

Abstract

Cotton production in West Africa is significantly constrained by insect pests, among which the leafhopper *Amrasca biguttula* has recently emerged as a major threat in Côte d'Ivoire. This study aimed to evaluate the impact of *A. biguttula* infestations and the effectiveness of insecticide treatments on the growth and yield of cotton (*Gossypium hirsutum*). A field experiment was conducted at the experimental farm of Peleforo Gon Coulibaly University using a randomized complete block design with three treatments: insecticide program A, insecticide program B, and untreated control. Agronomic parameters including plant height, number of leaves, flowers, and capsules were recorded weekly. The findings showed that insecticide treatments significantly improved plant growth and productivity compared to the untreated control. The highest values were recorded under treatment A, with a maximum plant height of 45.62 cm, 49.32 leaves, and 6.33 capsules per plant. In contrast, untreated plants exhibited reduced growth and yield due to severe pest attacks. The findings confirm the detrimental impact of *A. biguttula* on cotton development and highlight the importance of effective pest management strategies. Integrated pest management approaches are recommended to optimize cotton productivity while minimizing environmental risks.

Keywords: Cotton, *Amrasca biguttula*, insect pests, growth, yield, Côte d'Ivoire

Introduction

Cotton (*Gossypium hirsutum* L.) is one of the most important cash crops worldwide and plays a central role in the economies of many developing countries, particularly in West Africa. In Côte d'Ivoire, cotton production contributes significantly to rural incomes and export revenues, supporting thousands of smallholder farmers (Aïwa, 2015; Bini *et al.*, 2022) [1, 4]. Despite its economic importance, cotton productivity remains constrained by several biotic and abiotic factors, among which insect pests are the most damaging. Globally, cotton is attacked by more than 200 insect species, although only a limited number of cause significant economic losses (Oerke, 2006; Renou and Brévault, 2016) [14, 15]. In West Africa, pest infestations can lead to yield losses of up to 25% despite the use of chemical control measures (Oerke, 2006) [14]. Among these pests, sap-sucking insects such as aphids, whiteflies, and leafhoppers are particularly harmful because they directly affect plant physiology and indirectly transmit diseases (Ochou *et al.*, 2006) [13]. The leafhopper *Amrasca biguttula* (Ishida), commonly known as the cotton jassid, has recently emerged as a major pest in cotton-growing regions of Côte d'Ivoire. This insect feeds on the underside of leaves by piercing plant tissues and extracting sap. During feeding, it injects toxic saliva that disrupts photosynthesis, leading to chlorosis, leaf curling, and eventual defoliation (Badiane, 2023; Devi *et al.*, 2018) [3, 7]. Severe infestations can result in stunted plant growth and significant yield reductions. Recent reports indicate that *A. biguttula* infestations during the 2022–2023 growing season caused production losses exceeding 50% in some cotton-growing areas of Côte d'Ivoire (CNRA, 2023) [5]. Similar impacts have been reported in other African countries, where early infestations reduce plant vigor and reproductive capacity (Gnago *et al.*, 2020; Housseini *et al.*, 2024) [11, 12]. Although chemical control remains the primary method used to manage cotton pests, its effectiveness varies depending on the active ingredients and application strategies. Moreover, excessive reliance on insecticides raises concerns regarding environmental contamination, pest resistance, and human health risks (Badiane *et al.*, 2015) [2]. Despite the increasing importance of *A. biguttula*, limited information is available on its specific impact on cotton growth and yield under local conditions in Côte d'Ivoire. Understanding these effects is essential for optimizing pest management strategies and improving cotton productivity. Therefore, this study aimed to evaluate the impact of *A. biguttula* infestations and insecticide treatments on the agronomic performance of cotton. Specifically, it sought to: (i) assess plant growth parameters, (ii) determine the effect of pest control treatments on plant development, and (iii) evaluate their impact on yield components.

Materials and Methods

Study area

The study was conducted at the experimental field of Peleforo Gon Coulibaly University (UPGC) located in Korhogo, northern Côte d'Ivoire (between 8°30′–10°25′ N and 5°15′–6°20′ W) (Figure 1). The region is characterized by a Sudanian climate with two distinct seasons: a rainy season from May to October and a dry season from November to April (FAO, 2018; Aïwa, 2015) [1, 10]. Annual rainfall ranges between 1,000 and 1,300 mm, with peak precipitation occurring in July and August (Bini *et al.*, 2022) [4]. Average temperatures range from 25°C to 32°C, with higher temperatures recorded at the end of the dry season (Gnago *et al.*, 2020) [11]. The vegetation consists mainly of savannah formations, including shrub and tree savannahs (FAO, 2018) [10]. Soils in the study area are predominantly ferruginous and ferralitic, moderately fertile and suitable for cotton cultivation (CNRA, 2020; Housseini *et al.*, 2024) [12]. These agroecological conditions are representative of major cotton-growing zones in northern Côte d'Ivoire (Oerke, 2006; Diabaté *et al.*, 2024) [8, 14].

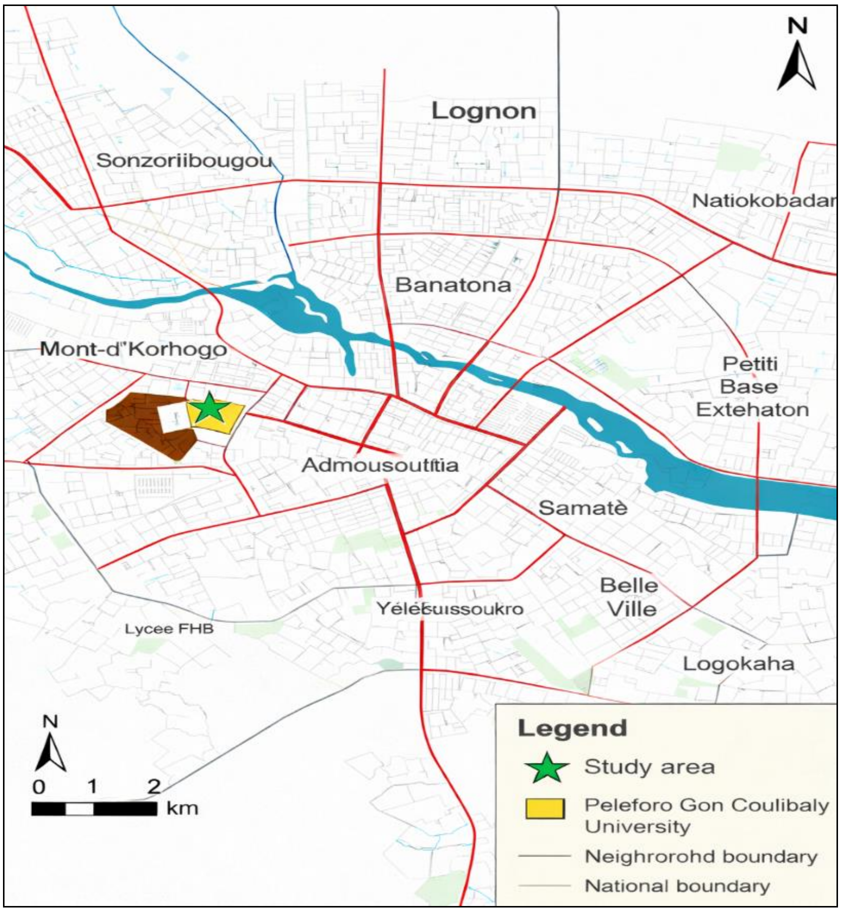

Fig 1: Location of the study sites

Plant material and target pest

The plant material used in this study was cotton (*Gossypium hirsutum* L.), the most widely cultivated species in Côte d'Ivoire due to its high productivity and adaptability. The target pest was the leafhopper *Amrasca biguttula* (Ishida), a polyphagous sap-sucking insect belonging to the family Cicadellidae. Both nymphs and adults feed on the underside of leaves, extracting sap and injecting toxic saliva that disrupts physiological processes such as photosynthesis. This results in symptoms including leaf curling, chlorosis, and reduced plant vigor.

Experimental design

The experiment was established using a randomized complete block design with three treatments and three replicates (Figure 2). The treatments were defined as follows:

- **Treatment A:** insecticide program recommended by company A
- **Treatment B:** insecticide program recommended by company B
- **Control (T0):** untreated plots

The total experimental area covered 5,244 m² (69 m × 76 m). Each block was separated by a 3 m buffer zone to minimize treatment interference, while plots within blocks were separated by 2 m. Each elementary plot consisted of 27 rows spaced 0.80 m apart. Within each row, planting holes were spaced at 0.30 m intervals. Each plot contained approximately 2,100 planting holes. For data collection, three representative rows (3rd, 14th, and 21st rows) were selected per plot. Within each row, three plants were randomly selected, resulting in a total of 9 sampled plants per plot and 81 plants for the entire experiment.

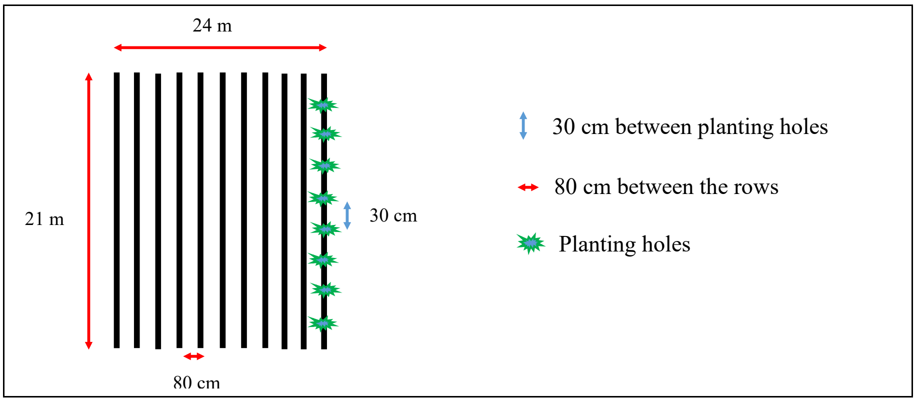

Fig 2: Experimental setup in a Fisher's randomized block design

Crop establishment and management

The experimental field was prepared through mechanical plowing using a tractor to ensure proper soil aeration and seedbed preparation. Sowing was carried out manually on June 15, 2024. Each planting hole received approximately five seeds. Germination occurred within 6–10 days after sowing. Thinning was performed 19 days after emergence to retain the two most vigorous plants per planting hole. This ensured an optimal plant density consistent with recommended agronomic practices. Fertilization was applied in two stages: (i) Basal application of NPK fertilizer immediately after thinning and (ii) top dressing with urea applied 30 days later. Fertilizers were applied along planting rows at approximately 5 cm from the plants and incorporated into the soil. Two manual weeding operations were conducted during the cropping cycle to reduce competition for nutrients, water, and light, and to limit pest habitat. Insecticide applications were carried out according to the treatment schedules provided by two cotton companies (A and B). Treatments began 40 days after sowing and were applied at 14-day intervals, except in cases of rainfall delays. Each treatment consisted of a sequence of insecticides with different active ingredients: Treatment A included: Fluxametamide; Pyridine + Diamine; Imidacloprid + Bifenthrin + Abamectin; Isoclast + Indoxacarb; Spirotetramate + Flubendiamide. Treatment B included: Pyridine + Diamine; Indoxacarb + Acetamiprid; Lambda-cyhalothrin + Acetamiprid; Flonicamid + Indoxacarb; Flonicamid. Applications were performed using a backpack sprayer to ensure uniform coverage of plant foliage.

Data Collection

Data were collected weekly from the 39th day after sowing until harvest. The following agronomic parameters were measured:

- **Plant height (cm):** measured from the base to the apex using a measuring tape ;
- **Number of leaves:** counted manually on each selected plant ;
- **Number of flowers:** counted during the flowering period ;
- **Number of capsules (bolls):** counted during the fruiting stage.

These parameters were selected to assess both vegetative growth and reproductive performance of the cotton plants.

Statistical Analysis

All collected data were subjected to statistical analysis using IBM SPSS software. Analysis of variance (ANOVA) was performed to evaluate the effect of treatments on measured parameters. When significant differences were detected ($p \leq 0.05$), means were separated using Tukey's Honestly Significant Difference (HSD) test. Data were expressed as mean ± standard deviation.

Results

Vegetative growth

Growth parameters increased over time in all treatments. However, treated plants showed significantly higher values. Treatment A recorded the highest plant height (45.62 cm), followed by treatment B (40.92 cm), while the control had the lowest growth (37.69 cm). A similar trend was observed for leaf numbers.

Evolution of leaf number

The number of leaves per plant increased progressively after sowing, reaching a peak before declining toward the end of the crop cycle (Table 1). At 95 days after sowing, treatment A recorded the highest mean leaf number (49.32 ± 7.43 leaves), which was significantly higher ($p < 0.05$) than treatment B (27.99 ± 1.72) and the control (25.03 ± 2.46). From 39 days after sowing, clear differences were already observed: (A: 17.03 ± 0.71; B: 10.11 ± 1.54; Control: 9.36 ± 0.89). These differences widened over time, indicating a cumulative effect of pest control on vegetative development. After the peak (95–109 days after sowing), leaf number declined across all treatments, reaching: (A: 14.84 ± 4.69; B: 7.36 ± 0.44; Control: 9.29 ± 2.59 at 144 days after sowing). This decline corresponds to leaf senescence and the transition toward reproductive maturity. Treatment A maintained a leaf area almost twice that of control at peak growth.

Table 1: Evolution of leaf number per plant according to treatments and time

Days after sowing	Treatment A (mean ± SD)	Treatment B (mean ± SD)	Control (mean ± SD)
39	17.03 ± 0.71^{a}	10.11 ± 1.54^{b}	9.36 ± 0.89^{b}
46	19.55 ± 3.18^{a}	11.88 ± 0.55^{b}	10.51 ± 0.90^{b}
53	21.51 ± 3.33^{a}	14.71 ± 1.10^{b}	11.73 ± 1.20^{b}
60	24.48 ± 4.65^{a}	15.88 ± 0.97^{b}	12.59 ± 1.42^{b}
67	29.84 ± 6.36^{a}	19.40 ± 4.16^{b}	15.03 ± 2.69^{b}
74	37.73 ± 8.72^{a}	22.73 ± 2.20^{b}	18.84 ± 3.24^{b}
81	43.66 ± 8.81^{a}	25.92 ± 2.06^{b}	21.66 ± 2.31^{b}
88	47.18 ± 8.38^{a}	27.14 ± 1.29^{b}	25.58 ± 5.72^{b}
95	49.32 ± 7.43^{a}	27.99 ± 1.72^{b}	25.03 ± 2.46^{b}
102	47.81 ± 5.73^{a}	25.03 ± 0.94^{b}	25.10 ± 2.99^{b}
109	45.88 ± 2.05^{a}	21.88 ± 1.44^{b}	25.77 ± 2.12^{b}
116	34.47 ± 3.23^{a}	17.14 ± 2.81^{b}	23.96 ± 1.84^{b}
123	31.32 ± 5.79^{a}	14.51 ± 3.05^{b}	22.62 ± 3.51^{ab}
130	20.40 ± 0.97^{a}	8.99 ± 2.12^{b}	15.37 ± 5.11^{ab}
137	17.66 ± 4.51^{a}	8.07 ± 0.45^{b}	11.36 ± 1.32^{ab}
144	14.84 ± 4.69^{a}	7.36 ± 0.44^{a}	9.29 ± 2.59^{a}

Values followed by the same letter in a row are not significantly different at $p \leq 0.05$ (Tukey test).

Evolution of plant height

Plant height followed a typical sigmoidal growth pattern, increasing rapidly during vegetative stages before stabilizing (Table 2). At 116 days after sowing, maximum heights were: Treatment A: 45.62 ± 8.06 cm; Treatment B: 40.38 ± 2.24 cm; Control: 37.42 ± 3.57 cm. Early differences appeared as soon as 46 days after sowing: (A: 18.91 ± 1.81 cm; Control: 14.87 ± 1.82 cm). Statistical analysis showed that differences were significant ($p < 0.05$) during key growth phases (95–102 days after sowing), confirming that pest pressure reduced plant vigor in untreated plots. Growth losses related to jassids are visible from the earliest stages → critical early effect.

Table 2: Evolution of plant height (cm) according to treatments and time

Days after sowing	Treatment A	Treatment B	Control
39	14.90 ± 0.33^{a}	14.27 ± 0.66^{a}	12.01 ± 0.30^{b}
46	18.91 ± 1.81^{a}	17.52 ± 0.65^{ab}	14.87 ± 1.82^{b}
53	23.00 ± 3.00^{a}	20.27 ± 1.11^{ab}	16.11 ± 2.17^{b}
60	26.08 ± 4.99^{a}	22.77 ± 0.43^{a}	18.92 ± 2.11^{a}
67	22.11 ± 1.72^{a}	27.26 ± 1.55^{a}	22.29 ± 2.24^{a}
74	34.54 ± 5.08^{a}	31.35 ± 0.61^{a}	25.88 ± 3.70^{a}
81	38.21 ± 5.18^{a}	35.47 ± 1.24^{a}	29.06 ± 4.09^{a}
88	40.89 ± 5.69^{a}	37.75 ± 1.07^{a}	30.69 ± 4.43^{a}
95	45.10 ± 6.04^{a}	39.53 ± 0.75^{ab}	32.79 ± 2.72^{b}
102	43.59 ± 7.39^{a}	40.92 ± 1.50^{ab}	34.85 ± 4.02^{b}
109	44.36 ± 6.84^{a}	40.88 ± 2.10^{a}	35.47 ± 2.91^{a}
116	45.62 ± 8.06^{a}	40.38 ± 2.24^{a}	37.42 ± 3.57^{a}
123	44.09 ± 6.21^{a}	39.85 ± 3.60^{a}	37.51 ± 3.75^{a}
130	43.62 ± 6.67^{a}	39.56 ± 3.41^{a}	37.69 ± 3.61^{a}
137	43.22 ± 7.04^{a}	39.14 ± 3.19^{a}	37.27 ± 3.86^{a}
144	43.43 ± 8.47^{a}	39.22 ± 3.52^{a}	37.21 ± 3.95^{a}

Values followed by the same letter in a row are not significantly different at $p \leq 0.05$ (Tukey test).

Reproductive development

Flower production

Flower production began 74 days after sowing (Table 3). Treatment A showed the highest flowering intensity, although differences were not always statistically significant. At this stage: (A: 0.74 ± 0.28 flowers; B: 0.55 ± 0.11; Control: 0.18 ± 0.06). The maximum flower production was recorded at 102 days after sowing: (A: 1.00 ± 0.22; B: 0.14 ± 0.16; Control: 0.40 ± 0.22). Although variability was high and differences were not always significant, treatment A consistently showed higher flowering potential. Leafhoppers affect flowering, but indirectly (via physiological stress).

Table 3: Evolution of flower number per plant

Days after sowing	Treatment A	Treatment B	Control
74	0.74 ± 0.28^{a}	0.55 ± 0.11^{ab}	0.18 ± 0.06^{b}
81	0.73 ± 0.28^{a}	0.62 ± 0.06^{a}	0.40 ± 0.16^{a}
88	0.66 ± 0.38^{a}	0.55 ± 0.29^{a}	0.18 ± 0.06^{a}
95	0.84 ± 0.05^{a}	0.36 ± 0.16^{b}	0.25 ± 0.22^{b}
102	1.00 ± 0.22^{a}	0.14 ± 0.16^{b}	0.40 ± 0.22^{b}
109	0.36 ± 0.22^{a}	0.18 ± 0.06^{a}	0.36 ± 0.22^{a}
116	0.36 ± 0.35^{a}	0.14 ± 0.16^{a}	0.29 ± 0.23^{a}
123	0.14 ± 0.06^{a}	0.07 ± 0.06^{a}	0.22 ± 0.29^{a}

Values followed by the same letter in a row are not significantly different at $p \leq 0.05$ (Tukey test).

Capsule production (yield component)

Capsule production showed the most pronounced treatment effect (Table 4). At 123 days after sowing, maximum capsule numbers were: (A: 6.33 ± 1.93; B: 3.62 ± 0.64; Control: 1.73 ± 0.95). At 130 days after sowing : (A: 5.96 ± 1.88; B: 3.10 ± 1.09; Control: 2.28 ± 0.92).

Table 4: Evolution of capsule number per plant

Days after sowing	Treatment A	Treatment B	Control
74	1.07 ± 0.75^{a}	0.55 ± 0.48^{a}	0.36 ± 0.12^{a}
81	1.81 ± 0.80^{a}	1.29 ± 0.83^{a}	0.95 ± 0.84^{a}
88	3.14 ± 0.99^{a}	2.32 ± 0.38^{ab}	1.18 ± 0.54^{b}
95	4.36 ± 1.00^{a}	3.03 ± 1.13^{a}	1.76 ± 1.04^{a}
102	5.66 ± 1.22^{a}	3.66 ± 0.94^{ab}	1.74 ± 0.86^{a}
109	6.26 ± 2.08^{a}	3.33 ± 0.57^{ab}	2.11 ± 1.12^{b}
116	6.33 ± 1.73^{a}	3.29 ± 0.71^{ab}	1.96 ± 0.96^{b}
123	6.33 ± 1.93^{a}	3.62 ± 0.64^{ab}	1.73 ± 0.95^{b}
130	5.96 ± 1.88^{a}	3.10 ± 1.09^{ab}	2.28 ± 0.92^{b}
137	6.03 ± 1.91^{a}	3.18 ± 0.71^{ab}	2.22 ± 0.33^{b}
144	6.18 ± 2.00^{a}	3.10 ± 0.77^{ab}	2.03 ± 0.44^{b}

Discussion

The results of this study clearly demonstrate that *Amrasca biguttula* has a significant negative impact on cotton growth and yield. Untreated plants exhibited reduced height, fewer leaves, and lower reproductive output compared to treated plants. These findings confirm that leafhopper infestations impair plant development by affecting physiological processes. The reduction in plant growth observed in untreated plots can be attributed to the feeding behavior of *A. biguttula*. As a sap-sucking insect, it extracts nutrients and injects toxic saliva, leading to chlorosis and reduced photosynthetic activity (Devi *et al*., 2018; Badiane, 2023) [3, 7]. This disruption in photosynthesis limits biomass accumulation and ultimately affects plant growth. Similar results have been reported by Housseini *et al.* (2024) [12], who showed that *A. biguttula* infestations significantly reduced plant vigor and leaf area in cotton. Likewise, Diabaté *et al.* (2024) [8] observed that heavy infestations caused defoliation and growth retardation, confirming the physiological stress induced by this pest. The significant increase in growth parameters under insecticide treatments highlights the effectiveness of chemical control in reducing pest pressure. Treatment A consistently outperformed treatment B, suggesting differences in the efficacy of active ingredients and application strategies. These results are consistent with previous studies showing that appropriate insecticide use can significantly improve cotton performance by protecting plants during critical growth stages (Badiane *et al*., 2015) [2]. Regarding yield components, the lower number of capsules observed in untreated plants indicates that *A. biguttula* infestations directly affect reproductive development. This may result from reduced assimilation availability due to impaired photosynthesis, leading to flower abortion and poor fruit set. Gnago *et al.* (2020) [11] reported similar findings, with significant reductions in capsule number and yield in untreated cotton plots exposed to leafhopper infestations. Furthermore, the delayed and reduced flowering observed in untreated plants suggests that pest attacks interfere with the transition from vegetative to reproductive stages. This phenomenon has also been documented in other studies, where pest-induced stress altered plant phenology and reduced reproductive success (Oerke, 2006) [14]. Although chemical control proved effective in this study, its long-term sustainability is questionable due to potential environmental and health risks. Excessive insecticide use can lead to pest resistance, environmental contamination, and negative impacts on non-target organisms (Badiane *et al*., 2015) [2]. Therefore, integrated pest management (IPM) strategies combining cultural practices, biological control, and selective pesticide use should be promoted.

Conclusion

This study demonstrated that *Amrasca biguttula* significantly reduces cotton growth and yield in northern Côte d'Ivoire. Insecticide treatments, particularly program A, effectively improved plant performance. Sustainable cotton production requires the adoption of integrated pest management strategies combining chemical and non-chemical approaches.

Author contributions

AMK and DC designed the study. KS collected data in the field and determined insect specimens and their traits. JBGG analyzed and plotted output data. DC wrote the first draft of the manuscript. YT contributed to improve the draft. All authors contributed substantially to revisions.

Data availability

Data of this study are available upon request from the corresponding author. The data are not publicly available due to privacy restrictions.

Conflict of interest

All authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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