

Relationship between Post-Flowering Insect Damage Parameters and Cowpea (*Vigna unguiculata* L. Walp.) Yield in Samaru, Northern Guinea Savanna, Nigeria

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ABSTRACT

Field trial comprising of intra-row spacings, sowing dates, and pesticides as a combination of Integrated Pest Management (IPM) was carried out on complex of pod sucking bugs (CPSBs) population during the rainy seasons of 2015 and 2016 respectively in Samaru. The experiment was laid out in split-split plot design with intra-row spacings allocated to the main plot, sowing dates to the sub-plot, and the sub-sub-plots were allocated to pesticides: The treatments were randomized and replicated three times. Data were measured on damage parameters caused by complex of pod-sucking bugs (CPSBs) and legume pod borer and correlated with yield. The result showed that post spray population of *Maruca vitrata* positively ($r > 0$) and strongly ($r > 0.5$) correlated with flower damage at 10 weeks after sowing (WAS) in each year and in the combined (0.967**, 0.740** and 0.816**). The yield positively and weakly correlates with percentage (%) CPSBs population at 10 WAS in 2015 (0.340**). Total cowpea grain yield was observed to negatively ($r < 0$) and significantly ($P \leq 0.05$) correlate with % dried cowpea pod damaged by *M. vitrata* at harvest (-0.253*) and % grain damaged by *M. vitrata* in 300 g (-0.355*). However, it negatively ($r < 0$) correlates with % grain damaged by *M. vitrata* in 300 g (-0.459** and -0.335**) as well as % grain damage by CPSBs in 300 g respectively and percentage grain damaged by CPSBs in 300 g (-0.508** and -0.422**) in 2016 and the combine results. It is recommended that varying cowpea sowing and use of pesticides intervention will reduce CPSBs population on cowpea and consequently reduce cowpea damage and increase yields substantially in the study area.

Keywords: Correlation, post-flowering insects, damage parameters, *Vigna unguiculata*, Northern guinea savanna, Nigeria

INTRODUCTION

Cowpea (*Vigna unguiculata* L. Walp.) is a major grain legume cultivated extensively across sub-Saharan Africa, where it plays a crucial role in human nutrition, household income, and soil fertility improvement through biological nitrogen fixation (Ajeigbe *et al.*, 2015; Boukar *et al.*, 2019). Nigeria remains the largest producer of cowpea globally, with production concentrated mainly in the savanna agro-ecologies (Maina *et al.*, 2016;

FAOSTAT, 2023). Despite its adaptation to harsh environments and low-input systems, cowpea yield levels on farmers' fields remain far below attainable potential due to multiple biotic and abiotic constraints, among which insect pests are the most damaging (Boukar *et al.*, 2020; Omoigui *et al.*, 2021).

Insect pests attacking cowpea during the reproductive and post-flowering stages constitute the most critical yield-limiting factors. These pests directly damage flowers, pods, and developing seeds, leading to reduced pod set, grain deformation, and severe yield losses (Karungi *et al.*, 2019; Ansar *et al.*, 2024). The legume pod borer, *Maruca vitrata* (Fab.) (Lepidoptera: Crambidae), is widely recognized as the most destructive post-flowering pest of cowpea in West Africa, capable of causing yield losses ranging from 20% to over 80% in untreated fields (Oerke, 2006; Soratur *et al.*, 2017; Boukar *et al.*, 2020). Larvae feed on flower buds, flowers, and pods, often webbing reproductive structures together and preventing normal seed development (Omoigui *et al.*, 2021). In addition to *M. vitrata*, several other insect pests significantly contribute to post-flowering damage in cowpea. Flower bud thrips, *Megalurothrips sjostedti* Trybom (Thysanoptera: Thripidae), infest floral tissues and cause flower abortion, malformation, and reduced pollen viability, ultimately leading to poor pod formation (Nderitu *et al.*, 2019; Karungi *et al.*, 2022). Pod-sucking bug complexes, including *Clavigralla tomentosicollis* Stål (Hemiptera: Coreidae), *Anoplocnemis curvipes* (F.) (Hemiptera: Coreidae), *Riptortus dentipes* (F.) (Hemiptera: Coreidae), and the green stink bug, *Nezara viridula* (L.) (Hemiptera: Pentatomidae), cause extensive damage by piercing pods and extracting sap from developing seeds, resulting in shriveled grains, reduced seed weight, and poor germination (Prasad *et al.*, 2021; Ansar *et al.*, 2024). Aphids, *Aphis craccivora* Koch (Homoptera: Aphididae) and whiteflies, *Bemisia tabaci* Genn. (Hemiptera: Aleyrodidae) further exacerbate yield losses through sap feeding and virus transmission (Allen *et al.*, 1996; Boukar *et al.*, 2019; Omoigui *et al.*, 2021).

These insect pests primarily target the reproductive organs of cowpea, making the flowering and early podding stages particularly vulnerable to yield loss. Muhammad *et al.* (2019) reported significantly higher flower damage by *M. vitrata* between 8 and 10 weeks after sowing in untreated cowpea plots. Similarly, severe infestations of flower thrips have been associated with high levels of flower drop and reduced pod set (Karungi *et al.*, 2022). Pod-sucking bug damage has been identified as the most economically important constraint during pod filling, as both nymphs and adults inflict direct seed injury and facilitate secondary infections by pathogens, further degrading grain quality (Wudil *et al.*, 2013; Prasad *et al.*, 2021). Overall, post-flowering insect pests account for the largest proportion of yield losses in cowpea production systems across the savanna agro-ecologies of West Africa (Oerke, 2006; Ansar *et al.*, 2024). Combined infestations of *M. vitrata* and pod-sucking bugs have been shown to reduce cowpea yield by more than 80% when effective pest management strategies are not employed (Karungi *et al.*, 2019; Boukar *et al.*, 2020). Maina *et al.* (2016) further demonstrated that severe flower and pod damage within 21 days after anthesis significantly reduced cowpea grain yield in northeastern Nigeria. In extreme cases, complete crop failure has been reported in farmers' fields where insect pests were left uncontrolled (Oyewale & Bamaiyi, 2013).

Beyond quantitative yield losses, post-flowering insect pests also negatively affect seed quality, germination capacity, and market value, thereby threatening food security and seed system sustainability (Omoigui *et al.*, 2021). Yield losses attributed to *M. vitrata* alone vary widely depending on cultivar resistance, planting date, pest pressure, and management practices (Boukar *et al.*, 2020). These losses disproportionately affect smallholder farmers, who often lack access to effective pest control technologies. Consequently, understanding the relationships between specific insect damage parameters and cowpea yield components is essential for improving pest management decisions and enhancing productivity. Therefore, this study was undertaken to examine the relationships between post-flowering insect pest damage parameters and cowpea yield in Samaru, northern guinea savanna.

MATERIALS AND METHODS

Study Location

An experiment was carried out within the northern guinea savanna agro-ecological zone during the 2015 and 2016 cropping seasons. The trial was conducted at Teaching and Research Farm, Institute for Agricultural Research, Ahmadu Bello University (IAR/ABU), Samaru, Zaria. The area lies between Latitudes 11° 10' N and Longitudes 07° 38' E, 686 meters above sea level (Eneh and Ati, 2010).

Preparation and Sources of Pest Control Products

Neem kernel seed extract (NKE) was prepared using mature neem (*Azadirachta indica*) seeds collected from natural stands around Katsina after rainfall events. Seeds were depulped, washed thoroughly, shade-dried, cracked, and the kernels milled into fine powder using an electric grinder. The extract was prepared by soaking 5 kg ha⁻¹ of neem kernel powder in 100 litre ha⁻¹ of water together with 2 kg ha⁻¹ of bar soap (used as an emulsifying agent) in water overnight. The mixture was agitated and filtered through clean cloth to obtain a uniform suspension. To enhance adhesion, liquid gum arabic was incorporated at a rate equivalent to 2.7 kg dissolved in 6.75 L of water per hectare. The *Maruca vitrata* multinucleopolyhedrovirus (MaviMNPV) formulation was sourced from the International Institute of Tropical Agriculture (IITA), Cotonou, Benin Republic. The viral suspension was prepared following established application protocols and diluted to a concentration of 7.57 × 10¹¹ occlusion bodies. A volume of 106 ml of the suspension was applied in 115 L of water per hectare. A synthetic insecticide, Cyper diforce®, a class II formulation containing cypermethrin (30 g L⁻¹) and dimethoate (250 g L⁻¹), was applied at a recommended rate of 1.5 L ha⁻¹. Applications were carried out using a CP-3 knapsack sprayer fitted with a hollow-cone nozzle to ensure uniform spray coverage (Muhammad *et al.*, 2021).

Experimental Treatments and Design

The experiment evaluated the combined effects of plant spacing (SP), sowing date (SD), and pesticide control treatments on insects' damage on cowpea yield. Treatments consisted of three intra-row spacings (SP1; 75 × 20 cm, SP2; 75 × 30 cm, and SP3; 75 × 40 cm), three planting dates (SD1; 2 July, SD2; 23 July, and SD3; 13 August), three pesticide (P) treatments: neem kernel seed extract (NKE), *Maruca vitrata* Multi-Nucleopolyhedrosis (MaviMNPV) viral suspension, synthetic insecticide (Cyper diforce®), and an untreated control. A split-split plot experimental design was adopted. Intra-row spacing was assigned to main plots, sowing dates to sub-plots, and pesticide

treatments to sub-sub-plots. Treatments were arranged in a randomized manner and replicated three times. Each experimental plot measured 6 m × 4.5 m (27 m²) and consisted of six ridges spaced 0.75 m apart. The two central rows constituted the net plot for, while adjacent rows served as sampling rows (flowers and pods) and outer rows as buffers. The same experimental layout was used in both cropping seasons Muhammad *et al.* (2021).

Crop Establishment and Field Management

The experimental field was mechanically ploughed, harrowed, and ridged prior to planting. The cowpea variety SAMPEA 7 was used throughout the study. Seeds were treated with Allstar® 40 SD (metalaxyl + imidacloprid) at the recommended rate to protect against early-season pests and diseases before sowing. Planting was carried out at three-week intervals according to the designated sowing dates, with three seeds sown per hole and later thinned to two plants per stand after establishment. Single superphosphate fertilizer was applied at 25 kg ha⁻¹ immediately after planting. Mancozeb (80% WP) was applied at the recommended rate for fungal disease control. Manual weeding was carried out at 3 and 6 weeks after sowing, and missing stands were replanted three weeks after emergence. Insecticide applications commenced at 7 weeks after sowing, coinciding with the onset of flowering. Spraying was conducted once weekly for four consecutive weeks between 06:00 and 07:00 h to minimize spray drift and photodegradation. Botanical and synthetic insecticides were applied using knapsack sprayers, while the viral formulation was applied with a hand-operated sprayer.

Data Collection and Damage Assessment

Data were collected on *Maruca vitrata* population density and damage intensity on cowpea flowers at 8, 9, and 10 weeks after sowing (WAS). Pod-sucking bug populations and pod damage were assessed at 9 and 10 WAS. Yield and damage parameters evaluated for correlation analysis included total grain yield (kg ha⁻¹), post-spray *M. vitrata* population in flowers at 10 WAS, flower damage by *M. vitrata*, percentage pod damage by *M. vitrata*, larval incidence in pods, proportion of dried pods damaged at harvest, percentage pod damage caused by cowpea pod-sucking bugs, percentage grain damage by *M. vitrata* and pod-sucking bugs in a 300 g grain sample, post-spray pod-sucking bug population at 10 WAS, and 100-seed weight (g). The data generated from the trial on crop against the insects were correlated against the final yield obtained.

Insect Sample and Identification

Post-flowering insect pest comprised of giant coreid bug, *Anoplocnemis curvipes* L. [Hemiptera: Coreoidea] (Plate 1) and spiny brown bug, *Clavigralla tomentosicollis* Stal. [Hemiptera: Coreoidea] (plate 2). Sampled insects were identified using a field guide book on pests, diseases, and nutritional disorders of the common bean in Africa (Allen *et al.*, 1996).



Plate 1: Giant coreid bug, *Anoplocnemis curvipes* L. [Hemiptera: Coreoidea]



Plate 2: Spiny brown bug, *Clavigralla tomentosicollis* Stal. [Hemiptera: Coreoidea]

Statistical Analysis

Pearson's correlation coefficients were computed to examine relationships between insect damage parameters and cowpea yield components. Pearson Correlation Coefficient (r) for a Two-tailed test at df - (N-2) at * $P \leq 0.05$ (r - 0.250) and at ** $P \leq 0.01$ (r - 0.325) significance was tested.

RESULTS

The result of correlation in Samaru during 2015 and 2016 cropping seasons and the combined is presented in Tables 1-3. The result showed that highly significant ($P \leq .01$), strong and positive correlation was observed between post spray *M. vitrata* populations in sampled flowers with post spray flower damaged by *M. vitrata* at 10 WAS (0.967**, 0.704** and 0.816**, respectively). Also the correlation result showed that total cowpea grain yield was observed to be negatively and significantly correlated with percentage dried cowpea pod damaged by *M. vitrata* at harvest (-0.253*), percentage grain damaged by *M. vitrata* in 300 g (-0.355*) and percentage grain damaged by CPSBs in 300 g (-0.422**). Similarly, 100 cowpea grain weight was observed to negatively and significantly ($P \leq 0.01$) correlate with percentage dried cowpea pod damaged by *M. vitrata* at harvest (-0.386**), percentage cowpea pod damaged by CPSB at harvest (-0.441**) as well as with percentage grain damaged by *M. vitrata* in 300 g (-0.435**).

Table 1: Correlation among Damage Parameters in Samaru during 2015 Cropping Season

	1	2	3	4	5	6	7	8	9	10	11
1.	1.000										
2.	0.129 ^{NS}	1.000									
3.	0.125 ^{NS}	0.967 ^{**}	1.000								
4.	0.267 [*]	0.369 ^{**}	0.361 ^{**}	1.000							
5.	0.201 ^{NS}	0.244 ^{NS}	0.198 ^{NS}	0.734 ^{**}	1.000						
6.	0.080 ^{NS}	0.129 ^{NS}	0.125 ^{NS}	0.267 [*]	0.129 ^{NS}	1.000					
7.	-0.098 ^{NS}	-0.002 ^{NS}	-0.042 ^{NS}	0.069 ^{NS}	-0.055 ^{NS}	-0.105 ^{NS}	1.000				
8.	0.259 [*]	0.154 ^{NS}	0.150 ^{NS}	0.379 ^{**}	0.315 [*]	0.259 [*]	0.018 ^{NS}	1.000			
9.	0.130 ^{NS}	0.222 ^{NS}	0.224 ^{NS}	0.335 ^{**}	0.329 ^{**}	0.130 ^{NS}	-0.000 ^{NS}	0.221 ^{NS}	1.000		
10.	0.340 ^{**}	0.152 ^{NS}	0.138 ^{NS}	0.117 ^{NS}	-0.082 ^{NS}	0.064 ^{NS}	0.088 ^{NS}	-0.002 ^{NS}	0.079 ^{NS}	1.000	
11.	0.022 ^{NS}	0.129 ^{NS}	0.125 ^{NS}	0.267 [*]	0.201 ^{NS}	0.810 ^{**}	-0.098 ^{NS}	0.259 [*]	0.130 ^{NS}	0.340 ^{**}	1.000

Key: 1 - Yield (kg ha⁻¹), 2 - Post spray *M. vitrata* populations in flowers at 10 WAS, 3 - Post spray flower damage by *M. vitrata* at 10 WAS, 4 - % cowpea pod damage by *M. vitrata* at 10 WAS, 5 - % *M. vitrata* populations in cowpea pods sampled 10 WAS, 6 - % dried cowpea pod damage by *M. vitrata* at harvest, 7 - % cowpea pod damaged by CPSB (Giant coreid bug and Spiny brown bug at harvest) at harvest, 8 - % grain damaged by *M. vitrata* in 300 g, 9 - % grain damaged by CPSB in 300 g, 10. Post spray populations of CPSB 10 WAS, 11- 100 cowpea grain weight (g), Pearson Correlation Coefficient for a Two-tailed test at df - (N-2) at * $P \leq .05$ (r - 0.250) and at ** $P \leq .01$ (r - 0.325).

Table 2: Correlation among Damage Parameters in Samaru during 2016 Cropping Season

	1	2	3	4	5	6	7	8	9	10	11
1.	1.000										
2.	0.005 ^{NS}	1.000									
3.	-0.034 ^{NS}	0.740 ^{**}	1.000								
4.	-0.026 ^{NS}	0.160 ^{NS}	0.222 ^{NS}	1.000							
5.	0.139 ^{NS}	0.172 ^{NS}	0.183 ^{NS}	0.012 ^{NS}	1.000						
6.	0.374 ^{**}	-0.045 ^{NS}	-0.125 ^{NS}	0.123 ^{NS}	-0.039 ^{NS}	1.000					
7.	0.696 ^{**}	-0.125 ^{NS}	-0.123 ^{NS}	-0.009 ^{NS}	-0.017 ^{NS}	0.518 ^{**}	1.000				
8.	-0.459 ^{**}	0.359 ^{**}	0.388 ^{**}	-0.098 ^{NS}	0.074 ^{NS}	-0.354 ^{**}	-0.491 ^{**}	1.000			
9.	-0.508 ^{**}	0.228 ^{NS}	0.213 ^{NS}	-0.024 ^{NS}	-0.002 ^{NS}	-0.209 ^{NS}	-0.403 ^{**}	0.821 ^{**}	1.000		
10.	-0.054 ^{NS}	0.009 ^{NS}	0.070 ^{NS}	0.108 ^{NS}	-0.048 ^{NS}	0.032 ^{NS}	-0.110 ^{NS}	0.023 ^{NS}	0.036 ^{NS}	1.000	
11.	0.320 [*]	-0.201 ^{NS}	0.267 [*]	0.081 ^{NS}	0.033 ^{NS}	0.094 ^{NS}	0.242 ^{NS}	-0.544 ^{**}	-0.589 ^{**}	-0.060 ^{NS}	1.000

Key: 1 - Yield (kg ha⁻¹), 2 - Post spray *M. vitrata* populations in flowers at 10 WAS, 3 - Post spray flower damage by *M. vitrata* at 10 WAS, 4 - % cowpea pod damage by *M. vitrata* at 10 WAS, 5 - % *M. vitrata* populations in cowpea pods sampled 10 WAS, 6 - % dried cowpea pod damage by *M. vitrata* at harvest, 7 - % cowpea pod damaged by CPSB (Giant coreid bug and Spiny brown bug at harvest) at harvest, 8 - % grain damaged by *M. vitrata* in 300 g, 9 - % grain damaged by CPSB in 300 g, 10. Post spray populations of CPSB 10 WAS, 11 - 100 cowpea grain weight (g), Pearson Correlation Coefficient for a Two-tailed test at df - (N-2) at * $P \leq .05$ (r - 0.250) and at ** $P \leq .01$ (r - 0.325).

Table 3: Combined Correlation among Damage Parameters in Samaru during 2015 and 2016 Cropping Seasons

	1	2	3	4	5	6	7	8	9	10	11
1.	1.000										
2.	0.039 ^{NS}	1.000									
3.	-0.013 ^{NS}	0.816 ^{**}	1.000								
4.	-0.136 ^{NS}	0.310 [*]	0.212 ^{NS}	1.000							
5.	-0.140 ^{NS}	0.201 ^{NS}	0.073 ^{NS}	0.695 ^{**}	1.000						
6.	-0.253 [*]	0.164 ^{NS}	0.205 ^{NS}	-0.075 ^{NS}	-0.100 ^{NS}	1.000					
7.	-0.246 ^{NS}	-0.062 ^{NS}	0.019 ^{NS}	-0.297 [*]	-0.277 [*]	0.328 [*]	1.000				
8.	-0.335 [*]	0.227 ^{NS}	0.301 [*]	-0.034 ^{NS}	-0.005 ^{NS}	0.249 ^{NS}	0.249 ^{NS}	1.000			
9.	-0.422 ^{**}	0.244 ^{NS}	0.204 ^{NS}	0.277 [*]	0.312 [*]	-0.096 ^{NS}	-0.096 ^{NS}	0.456 ^{**}	1.000		
10.	0.032 ^{NS}	0.043 ^{NS}	0.054 ^{NS}	-0.067 ^{NS}	-0.110 ^{NS}	0.021 ^{NS}	0.106 ^{NS}	0.002 ^{NS}	-0.088 ^{NS}	1.000	
11.	0.078 ^{NS}	-0.050 ^{NS}	-0.174 ^{NS}	0.359 ^{**}	0.295 [*]	-0.386 ^{**}	-0.441 ^{**}	-0.435 ^{**}	-0.024 ^{NS}	-0.171 ^{NS}	1.000

Key: 1 - Yield (kg ha⁻¹), 2 - Post spray *M. vitrata* populations in flowers at 10 WAS, 3 - Post spray flower damage by *M. vitrata* at 10 WAS, 4 - % cowpea pod damage by *M. vitrata* at 10 WAS, 5 - % *M. vitrata* populations in cowpea pods sampled 10 WAS, 6 - % dried cowpea pod damage by *M. vitrata* at harvest, 7 - % cowpea pod damaged by CPSB (Giant coreid bug and Spiny brown bug at harvest), 8 - % grain damaged by *M. vitrata* in 300 g, 9 - % grain damaged by CPSB in 300 g, 10. Post spray populations of CPSB 10 WAS, 11 - 100 cowpea grain weight (g), Pearson Correlation Coefficient for a Two-tailed test at df - (N-2) at * $P \leq .05$ (r - 0.250) and at ** $P \leq .01$ (r - 0.325).

DISCUSSION

Relationships among Damage Parameters and Cowpea Yield

The correlation analysis revealed a complex pattern of positive and negative associations among post-flowering insect damage variables and cowpea yield across seasons and in the combined data set. The consistently strong correlations observed between insect population density, flower and pod damage, and grain yield clearly demonstrate that reproductive damage is closely linked to pest abundance. Cowpea yield was strongly dependent on the proportion of flowers that survived insect attack and successfully developed into pods, underscoring the critical importance of the flowering stage in determining final productivity.

The strong positive associations between *M. vitrata* population levels and damage indices indicate that increases in pest density directly translated into higher levels of flower and pod destruction. This confirms that reproductive organs are the most vulnerable components of the cowpea plant and that damage at this stage has irreversible consequences for yield formation. Flower loss reduces pod initiation, while pod injury directly compromises seed development, resulting in lower grain number and reduced seed weight. Similar patterns have been reported in other cowpea-growing regions, where flower-feeding pests caused yield reductions proportional to their population intensity (Doumbia *et al.*, 2019). Previous studies have shown positive correlations between pod number, seed weight, and final grain yield in cowpea, indicating that improvements in these components enhance productivity (Boukar *et al.*, 2019). Negative correlations ($r < 0$) between cowpea yield and damage parameters further highlight the suppressive effect of post-flowering insect pests on productivity. As infestation intensity increased, yield declined markedly (Akoglu, 2018), confirming that *M. vitrata* and cowpea pod-sucking bugs are among the most important biotic yield-limiting factors in the agro-ecology. Damage inflicted during the critical reproductive window, particularly shortly after anthesis, had the greatest influence on yield reduction. This observation supports earlier findings that severe flower and pod damage within the first three weeks after anthesis significantly impairs grain yield (Maina *et al.*, 2016).

The observed relationships also emphasized the cumulative effect of pest complexes rather than the influence of a single species. The combined activity of *M. vitrata* and pod-sucking bugs amplified reproductive damage, resulting in compounded yield losses. This interaction explains the strong correlations between multiple damage indices and yield components. The present findings are consistent with earlier reports that documented significant negative relationships between cowpea grain yield and levels of flower infestation in savanna agro-ecosystems (Ajeigbe *et al.*, 2012). Collectively, these results demonstrate that effective management of post-flowering insect pests is essential for stabilizing cowpea yield under rain-fed conditions. For example, damage caused by *M. vitrata* and pod-sucking bugs has been reported to significantly reduce pod formation and grain yield, resulting in strong negative correlations between damage intensity and yield (Oerke, 2006; Mukaka, 2012).

CONCLUSION

Post-flowering insect pests constitute the most severe biological constraint to cowpea production in savanna agro-ecosystems. Among these pests, pod-sucking bugs such as *Clavigralla tomentosicollis* and *Anoplocnemis curvipes* are particularly destructive due

to their direct feeding on developing pods and seeds. Their piercing-sucking activity results in empty pods, shriveled grains, reduced seed weight, and poor grain quality, all of which substantially reduce marketable yield. The strong correlations observed between insect damage parameters and cowpea yield demonstrate that reproductive damage is a reliable predictor of yield loss. Yield reduction was closely associated with the intensity of flower and pod damage, confirming that the flowering and early pod-filling stages are critical periods for pest intervention. These findings underscore the need for management strategies that target pest populations during these vulnerable growth stages.

Adopting agronomic practices such as adjustment of sowing dates to avoid peak pest pressure, combined with judicious use of insecticides, can significantly reduce pest populations and associated damage. Minimizing indiscriminate insecticide use while integrating alternative control measures will not only enhance yield and economic returns for farmers but also promote environmental sustainability. Overall, improved understanding of pest–damage–yield relationships provides a valuable foundation for developing effective integrated pest management strategies aimed at increasing cowpea productivity and strengthening food security in the study area.

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CONFLICT OF INTEREST

The authors have no conflicts of interest to declare that are relevant to the content of this article.

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