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EFFICACY OF 3G KARAISAL FOLIAR APPLICATION FOR ECO-FRIENDLY MANAGEMENT OF PESTS IN COWPEA (*VIGNA UNGUICULATA* L.)

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ABSTRACT

The present study evaluated the efficacy of 3G karaisal foliar application against major insect pests of cowpea under field conditions. Treatments ranging from 1% to 7% concentrations were tested, with pest incidence and phytotoxicity being recorded. Results revealed a clear dose-dependent trend, with lower concentrations (1–2%) providing only marginal suppression, while 3% spray achieved moderate reduction in aphids, whiteflies, pod bugs and leaf miners without phytotoxic effects. The 4% foliar application was most effective, recording over 65–75% pest suppression with no visible crop injury, thereby establishing the optimum concentration for field use. Higher concentrations (5–7%) offered comparable or greater pest reduction but induced phytotoxic symptoms such as leaf tip burn and chlorosis, limiting their agronomic suitability. Overall, 4% 3G karaisal proved to be an eco-friendly and effective botanical option for sustainable cowpea pest management.
***Keywords* :** 3G karaisal, cowpea, foliar spray, phytotoxicity.

Introduction

Cowpea (*Vigna unguiculata* L. Walp.) is an important leguminous crop grown extensively for its high nutritional value, short growth duration, and ability to enrich soil fertility through nitrogen fixation. It plays a significant role in food security and income generation for smallholder farmers, particularly in semi-arid regions. Despite its potential, cowpea cultivation is constrained by a wide range of insect pests that considerably reduce yield and quality. According to Lin *et al*. (2025), more than 200 insect species have been reported on cowpea, of which aphids (*Aphis craccivora*), pod bugs (*Riptortus pedestris*), whiteflies (*Bemisia tabaci*) and leaf miners (*Liriomyza* spp.) are of major concern. These pests not only inflict direct feeding damage but also act as vectors of viral diseases (Lin *et al*., 2025). In India, the incidence of aphids and whiteflies is most prominent during early vegetative and flowering stages, while pod bugs and leaf miners occur from flowering to pod formation stages, causing significant yield losses (Karthickraja and Saravanane, 2025).

Chemical pesticides are widely employed in cowpea pest management; however, their indiscriminate use has resulted in pest resurgence, resistance development, environmental pollution and residue hazards (Karthickraja *et al*., 2024). Furthermore, exposure to synthetic pesticides poses health risks to farmers and consumers. Hence, there is a growing need for safer, cost-effective, and sustainable pest management alternatives. In this context, botanical pesticides have emerged as promising solutions due to their biodegradability, selectivity and low mammalian toxicity. Plant-based extracts exhibit diverse modes of action, including antifeedant, repellent, ovicidal and insecticidal effects. Garlic (*Allium sativum*) contains *allicin*, a sulphur compound with insecticidal, antibacterial and fungicidal properties (Rajapaksha *et al*., 2024). Green chilli (*Capsicum annuum*) is rich in *capsaicin*, which acts as a feeding deterrent and neurotoxic agent to softbodied insects (Chabaane *et al.*, 2021). Ginger (*Zingiber officinale*) contains *gingerol* and *zingerone*, which exhibit both repellent and toxic effects on several insect species (Sharma *et al.*, 2024). Although individually these extracts have demonstrated effectiveness in suppressing aphids, whiteflies and other sucking pests, combined formulations such as the 3G extract are believed to provide synergistic effects and broader-spectrum pest control.

Studies support this hypothesis, as the combination of garlic, green chilli and ginger has shown higher efficacy compared to individual extracts due to the synergistic action of multiple bioactive compounds. Sharma *et al.* (2024) reported that 3G extract at 5% concentration effectively reduced aphid populations in brinjal and okra, while Thodusu *et al.* (2024) observed significant reductions in whiteflies and thrips in chilli and tomato treated with 3G mixtures. In legume crops, particularly cowpea, the use of such botanical formulations has been less explored. However, localized trials and farmer participatory research have shown that 3G formulations can substantially reduce pest incidence with minimal ecological disruption. Creating awareness among farming communities about the benefits of natural pest control methods is essential for promoting sustainable agriculture. Aroulradj *et al.* (2025) emphasized that demonstration trials using low-cost botanical extracts on farmers' fields enhance farmer confidence in adopting eco-friendly practices. Therefore, the present study was undertaken to evaluate the bio-efficacy of 3G organic extract at varying concentrations for the management of major insect pests in cowpea and to disseminate its practical applicability to farming communities in and around Hosur.

Materials and Methods

Experimental site and crop details

The field experiment was conducted during the May season of 2025 at the Institutional Farm of Adhiyamaan College of Agriculture and Research (ACAR), Hosur, situated in Krishnagiri district of Tamil Nadu. The farm is geographically located at 12.8207° N latitude and 78.0215° E longitude, with an altitude of 804 meters above mean sea level. The experimental site is characterized by red loamy soils, moderate rainfall and average temperatures ranging from 25°C to 32°C during the cropping period. The test crop was cowpea (*Vigna unguiculata* L.), and the variety used was COCP 7, a short-duration type valued for its early maturity, good pod setting and susceptibility to major sucking pests and foliage feeders, making it suitable for bio-efficacy studies.

Preparation of 3G extract

The organic pesticide, referred to as 3G extract, was prepared using equal proportions of fresh green chilli (*Capsicum annuum*), garlic cloves (*Allium sativum*) and ginger rhizomes (*Zingiber officinale*). Eighteen grams of garlic cloves were peeled and ground into a paste, while 9 g each of green chilli and ginger were similarly processed into paste. These were combined in 1 liter of water, stirred thoroughly and filtered through a muslin cloth. For spraying, 500 ml of the filtrate was mixed with 100 ml of soap solution (as a surfactant) and diluted with 9.4 litres of water, resulting in a 10-litre spray solution.

Treatments and experimental design

The study consisted of eight treatments, laid out in a Randomized Block Design (RBD) with three replications. Each plot measured 4 m × 3 m, with a spacing of 45 cm between rows and 15 cm between plants. Treatments were as follows: foliar sprays of 3G karaisal at 1% (T_1), 2% (T_2), 3% (T_3), 4% (T_4), 5% (T_5), 6% (T_6) and 7% (T_7), while T_8 served as the untreated control. Sprays were applied at the flowering stage of cowpea, coinciding with the peak activity of key insect pests such as aphids, whiteflies, pod bugs and leaf miners. Applications were performed using a knapsack sprayer fitted with a cone nozzle to ensure uniform coverage of the foliage. Two sprays were given at 10-day intervals and observations on pest dynamics and crop safety were recorded before spray, 3 and 5 days after spraying (DAS).

Observations recorded

The primary focus of the study was on pest incidence and treatment efficacy. Pest populations were recorded by counting aphids, whiteflies, pod bugs and leaf miners from five randomly selected plants per plot, both before spraying and at 3 and 5 DAS. The data were averaged for each treatment. Phytotoxicity symptoms such as leaf burn, stunting, or discoloration were also recorded to assess crop safety, and severity was scored using a standard crop injury rating scale (Table 1). The pest mortality percentage and percent reduction were calculated using the formula.

$$\text{Pest mortality percentage} = \frac{\text{Number of dead pest}}{\text{Total pest population}} \times 100$$

$$\text{Percent reduction over control} = \frac{\text{Pest population in control} - \text{Pest population in treatment}}{\text{Pest population in control}} \times 100$$

Statistical analysis

The experimental data were subjected to Analysis of Variance (ANOVA) using R software (R Core Team, 2018), and treatment means were compared using the Critical Difference (CD) at 5% probability level ($P \leq 0.05$). To stabilize variance and ensure statistical validity, pest population data were log-transformed using the equation $Y = \log_{10}(X)$ before analysis.

Results and Discussion

The efficacy of 3G karaisal foliar application against major insect pests of cowpea varied significantly with treatment concentrations, with the results exhibiting a clear dose-dependent trend. At a lower concentration of 1% (T_1), pest suppression was minimal, with less than 25% reduction recorded across aphids, whiteflies and pod bugs (Table 2, 3, 4). The relatively poor performance indicates that the concentration was below the threshold required for sufficient release of bioactive metabolites, such as sulphur compounds and flavonoids, to exert a significant insecticidal effect. Such weak responses at sub-lethal doses have also been documented by Hussein *et al.* (2025), who observed that diluted botanical extracts failed to suppress whitefly incidence in legumes. Nevertheless, no phytotoxic symptoms were detected at this level (Table 5), confirming crop safety, though its utility under heavy infestation appears limited. A moderate improvement was observed in the 2% foliar spray (T_2), where suppression increased to 35–45% depending on the pest species. Aphid and whitefly populations declined more noticeably compared to T_1, indicating the beginning of a biologically meaningful response. This suggests that bioactive compounds like allicin and sulphur volatiles in 3G karaisal became sufficiently concentrated to exert feeding deterrence and disrupt oviposition. Comparable findings were reported by Tembo *et al.* (2018), who demonstrated that neem kernel extract exhibited similar intermediate effects at 2% concentration. No phytotoxicity was recorded, suggesting that crop safety remains intact, though the reduction levels achieved were still inadequate for use under field conditions with high pest pressure. 3% foliar application of 3G karaisal (T_3) exhibited a distinct improvement, with pod bug reduction exceeding 50% and aphid suppression becoming prominent by 5 DAS. This indicates that the concentration was approaching the optimum threshold required for effective deterrence and mortality. The consistency of these results with Hussein *et al.* (2025), who reported strong feeding inhibition from garlic and onion extracts at similar doses, underscores the biological potential of 3% applications. Despite the higher metabolite content, cowpea plants exhibited no phytotoxicity, suggesting that the crop could tolerate this concentration without physiological stress. Therefore, 3% application can be considered effective under moderate pest pressure with acceptable crop safety.

The 4% foliar application of 3G karaisal (T_4) proved to be the most effective treatment, showing more than 65% reduction in aphids and over 75% suppression of pod bugs and leaf miners by 5 DAS. The superiority of T_4 is evident in Figure 1 and 2, which clearly illustrate the significant decline in pest populations compared to the control. Importantly, phytotoxicity symptoms were absent, indicating that this concentration provided an optimum balance between efficacy and crop safety. The mechanisms underlying this effectiveness may include direct insecticidal action through cuticle disruption, feeding deterrence, repellence and possibly the induction of systemic resistance in cowpea, mediated through enhanced activity of defence enzymes such as peroxidase and polyphenol oxidase. Similar findings were reported by Tembo *et al.* (2018), who observed that botanical extracts at 4% concentration produced maximum pest suppression without negative crop effects. This highlights T_4 as the most practical and reliable recommendation for field use. Although the 5% spray (T_5) produced pest reduction levels comparable to T_4, marginal phytotoxicity symptoms such as leaf edge yellowing were observed at 5 DAS. The symptoms suggest osmotic stress and possible interference of high sulphur-based volatiles with chlorophyll stability. While Hammad et al. (2000) similarly reported leaf tip necrosis in cowpea with higher concentrations of pongamia extracts, the phytotoxicity recorded in the present study implies that 5% sprays, despite their efficacy, should be used with caution. The 6% foliar application of 3G karaisal (T_6) maintained high pest suppression of around 75%, but phytotoxicity symptoms became more evident, including leaf tip burn and mild growth stunting. This indicates that although insecticidal potential increases with dose, crop tolerance declines. The damage may be associated with oxidative stress and reduced stomatal conductance, which compromise photosynthetic activity (Yazhini *et al.*, 2025). Thus, while biologically effective, T_6 cannot be considered agronomically suitable for cowpea protection. At a higher concentration of 7% (T_7), pest suppression remained strong and, in some cases, exceeded the reductions observed in T_4 and T_5. However, the treatment was consistently associated with severe phytotoxicity, including chlorosis and necrosis. The results suggest that 7% sprays exceed the tolerance threshold of cowpea, rendering the treatment unsuitable for practical pest management. Hammad *et al.* (2000) and Panwar et al. (2025) similarly reported that excessive botanical concentrations in legumes compromised plant growth despite effective pest control. As expected, the untreated control (T_8) maintained huge pest populations across all observation intervals, thereby validating the relative efficacy of all treatments (Elakkiya *et al.*, 2025). The overall results demonstrate that while increasing concentrations of 3G karaisal enhanced pest suppression, phytotoxicity symptoms also intensified beyond 4%.

Conclusion

The present study demonstrated that foliar application of 3G karaisal exerts significant insecticidal effects against major insect pests of cowpea in a clear dose-dependent manner. Lower concentrations (1–2%) provided only marginal suppression, while intermediate levels (3%) achieved moderate pest reduction without compromising crop safety. The 4% foliar spray emerged as the most effective treatment, recording over 65–75% suppression of aphids, whiteflies, pod bugs and leaf miners, with no phytotoxic symptoms, thereby establishing it as the optimum concentration for field application. Although higher doses (5–7%) further reduced pest incidence, they induced phytotoxic effects ranging from leaf edge yellowing to necrosis, rendering them agronomically unsuitable despite their insecticidal potential. These findings highlight 4% 3G karaisal as a promising eco-friendly alternative to synthetic insecticides for cowpea pest management.

Table 1 : Crop injury score (Crop phytotoxicity)

Rating	Effect	Crop injury symptoms
0	None	No injury
1	Slight	Slight stunting, Injury or Discoloration
2		Some stand loss, Stunting and discoloration
3		Injury more pronounced but not persistent
4	Moderate	Moderate injury and recovery possible
5		Injury more persistent and recovery doubtful
6		More severe injury and recovery not possible
7	Severe	Severe injury and Stand loss
8		Almost destroyed, few plants surviving
9		Very few plants alive
10	Complete	Complete destruction

Table 2 : Pre-treatment pest population in cowpea before foliar applications

Treatment		Pest population before spray			
		Aphid	Leaf minor	Whitefly	Pod bug
T_1	1% Foliar application of 3G karaisal	2.75 (564.0)^a	1.13 (13.7)^a	1.06 (11.7)^a	1.04 (11.0)^a
T_2	2% Foliar application of 3G karaisal	2.67 (473.0)^a	1.12 (13.3)^a	1.12 (13.3)^a	1.05 (11.3)^a
T_3	3% Foliar application of 3G karaisal	2.70 (502.7)^a	1.04 (11.0)^a	1.09 (12.3)^a	1.06 (11.7)^a
T_4	4% Foliar application of 3G karaisal	2.67 (475.7)^a	1.05 (11.3)^a	1.07 (12.0)^a	1.05 (11.3)^a
T_5	5% Foliar application of 3G karaisal	2.70 (506.7)^a	1.09 (12.3)^a	1.17 (15.0)^a	1.04 (11.0)^a
T_6	6% Foliar application of 3G karaisal	2.71 (513.7)^a	1.01 (10.3)^a	1.12 (13.3)^a	1.11 (13.0)^a
T_7	7% Foliar application of 3G karaisal	2.64 (438.6)^a	1.01 (10.3)^a	1.10 (12.7)^a	1.10 (12.7)^a
T_8	Control	2.80 (635.3)^a	1.17 (15.0)^a	1.30 (20.3)^a	1.20 (16.0)^a
S. Ed.		0.06	0.12	0.11	0.08
C.D. ($P \leq 0.05$)		NS	NS	NS	NS

Table 3 : Effect of foliar applications on pest population in cowpea at 3 DAS

Treatment		Pest population on 3rd day after spray			
		Aphid	Leaf minor	Whitefly	Pod bug
T_1	1% Foliar application of 3G karaisal	2.65 (446.0)^{bc}	1.01 (10.3)^b	1.04 (11.0)^b	0.80 (6.3)^{ab}
T_2	2% Foliar application of 3G karaisal	2.41 (260.0)^{ab}	1.02 (10.7)^b	1.02 (10.7)^b	0.77 (6.0)^a
T_3	3% Foliar application of 3G karaisal	2.55 (353.3)^b	0.97 (9.3)^b	0.93 (8.7)^{ab}	0.72 (5.3)^a
T_4	4% Foliar application of 3G karaisal	2.24 (173.3)^a	0.66 (4.7)^a	0.86 (7.3)^a	0.56 (3.7)^a
T_5	5% Foliar application of 3G karaisal	2.28 (192.3)^a	0.84 (7.0)^{ab}	1.04 (11.0)^{bc}	0.42 (2.7)^a
T_6	6% Foliar application of 3G karaisal	2.28 (189.0)^a	0.60 (4.0)^a	0.86 (7.3)^a	0.63 (4.3)^a
T_7	7% Foliar application of 3G karaisal	2.24 (173.0)^a	0.56 (3.7)^a	0.69 (5.0)^a	0.52 (3.3)^a
T_8	Control	2.78 (608.3)^c	1.13 (13.7)^b	1.28 (19.3)^c	1.13 (13.7)^b
S. Ed.		0.14	0.17	0.13	0.22
C.D. ($P \leq 0.05$)		0.3	0.4	0.3	0.4

Table 4 : Effect of foliar applications on pest population in cowpea at 5 DAS

Treatment		Pest population on 5th day after spray			
		Aphid	Leaf minor	Whitefly	Pod bug
T_1	1% Foliar application of 3G karaisal	2.44 (280.0)[bc]	1.13 (13.7)[ab]	1.06 (11.7)[a]	1.04 (11.0)[a]
T_2	2% Foliar application of 3G karaisal	2.21 (165.0)[a]	1.12 (13.3)[a]	1.12 (13.3)[a]	1.05 (11.3)[a]
T_3	3% Foliar application of 3G karaisal	2.43 (270.0)[b]	1.04 (11.0)[a]	1.09 (12.3)[a]	1.06 (11.7)[a]
T_4	4% Foliar application of 3G karaisal	2.14 (138.3)[a]	1.05 (11.3)[a]	1.07 (12.0)[a]	1.05 (11.3)[a]
T_5	5% Foliar application of 3G karaisal	2.22 (166.7)[ab]	1.09 (12.3)[a]	1.17 (15.0)[ab]	1.04 (11.0)[a]
T_6	6% Foliar application of 3G karaisal	2.14 (138.3)[a]	1.01 (10.3)[a]	1.12 (13.3)[a]	1.11 (13.0)[ab]
T_7	7% Foliar application of 3G karaisal	2.09 (125.0)[a]	1.01 (10.3)[a]	1.10 (12.7)[a]	1.10 (12.7)[a]
T_8	Control	2.63 (433.0)[c]	1.17 (15.0)[b]	1.30 (20.3)[b]	1.20 (16.0)[b]
S. Ed.		0.14	0.11	0.11	0.11
C.D. ($P \leq 0.05$)		0.3	0.1	0.2	0.1

Table 5 : Phytotoxicity observations recorded at 3and 5 DAS in cowpea

Treatment		Phytotoxicity observations	
		3rd DAS	5th DAS
T_1	1% Foliar application of 3G karaisal	0	0
T_2	2% Foliar application of 3G karaisal	0	0
T_3	3% Foliar application of 3G karaisal	0	1
T_4	4% Foliar application of 3G karaisal	0	1
T_5	5% Foliar application of 3G karaisal	0	1
T_6	6% Foliar application of 3G karaisal	1	2
T_7	7% Foliar application of 3G karaisal	1	2
T_8	Control	0	0

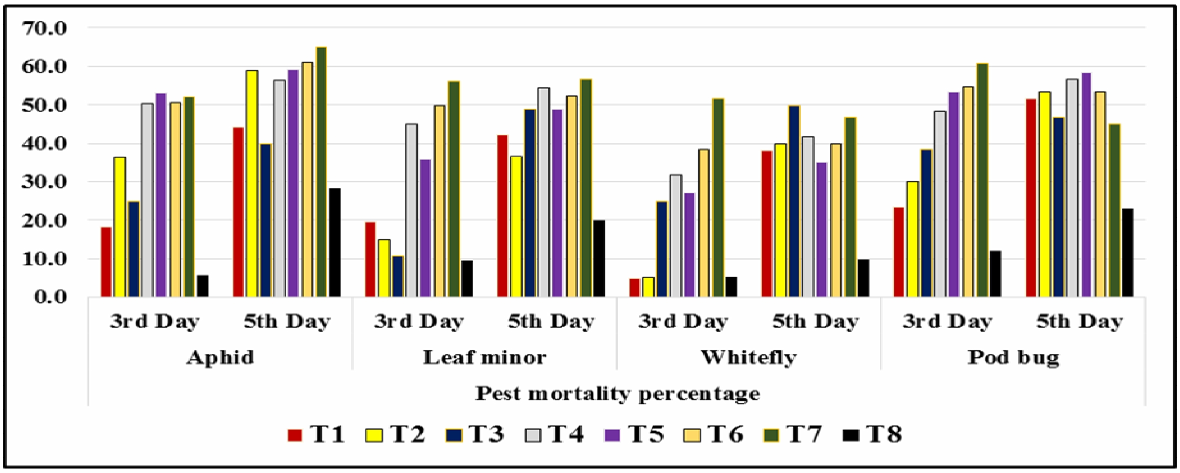

Fig. 1 : Pest mortality percentage of observed pests at 3 and 5 DAS

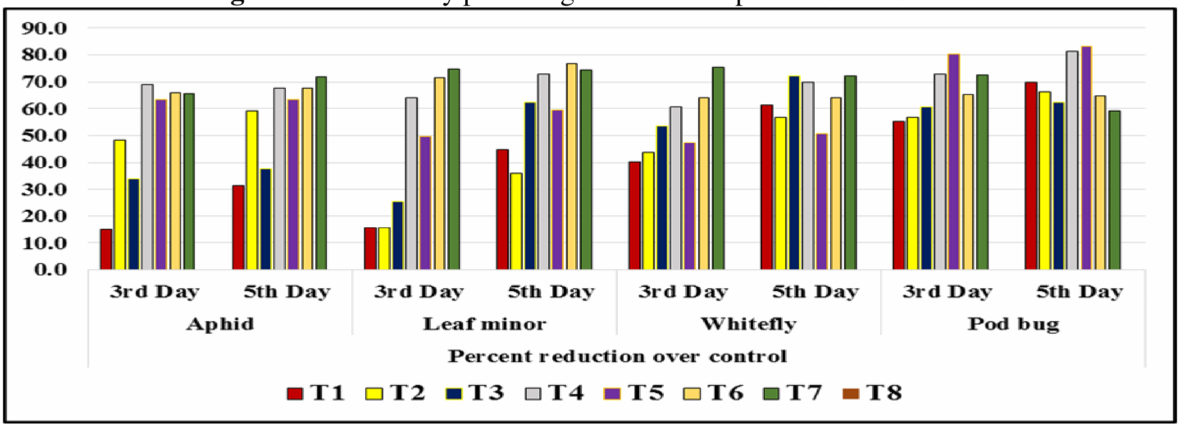

Fig. 2 : Percent reduction over control of observed pests at 3 and 5 DAS

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Declaration

The authors should declare that they do not have any conflict of interest.

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