Eco-Friendly Management of Cowpea Pests Using local Plant Extracts in Ngaoundere, Cameroon

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Submitted 05/11/2025, Published online on 31st January 2026 in the *Journal of Animal and Plant Sciences (J. Anim. Plant Sci.) ISSN 2071 – 7024*

1 ABSTRACT

Crop cultivation, which often depends on the application of chemical pesticides, leads to environmental and people's health issues, and it is really important to look into greener options. Some local plants, such as *Annona senegalensis*, *Chromolaena odorata*, and *Eucalyptus camaldulensis*, have been used as insect pest killers for some time. This present study checked out how effective these plant extracts worked at different dosages (5%, 10%, and 15%) to control cowpea pests on cowpea plants in Ngaoundere, Cameroon. We conducted field tests for two rainy seasons (2023 and 2024), using a setup where we randomly applied eleven treatments with four replicates. One treatment was considered the negative control. In total, we recorded 2,458 in 2023 and 2,628 in 2024 on cowpea plants. The most common insect pest was *Aphis craccivora*, followed by *Ootheca mutabilis*. : The results revealed that treatments based on *E. camaldulensis* and *A. senegalensis* treatments have strong insect pest-killing potential because they contain compounds with adulticidal properties. They also seemed to repel insect pests. The plant extracts lowered the number of bugs compared to the untreated control, especially *E. camaldulensis* and *A. senegalensis* extracts. Therefore, these extracts could be better and sustainable options for managing bugs instead of using synthetic insecticides. As we mostly found sap-sucking bugs and leaf-feeders, it makes sense to use a pest management strategy that includes plant extracts, which is ecofriendly.

2 INTRODUCTION

Vigna unguiculata (L.) Walp commonly known as cowpea, is one of the most extensively cropped species cultivated in Africa (Camara *et al*., 2024). It is a member of the Fabaceae family (Abebe & Alemayehu, 2022) with an average protein content ranging from 17 to 27 % in its composition with protein representing a viable alternative to soy and other conventional source (Oliveira *et al*., 2025). Thus, cowpea constitutes an importante dietary component, especially for popolations with limited financial means and reduced availability of animal protein (Roland *et al*., 2023). Through its ability to provide soil cover, fix atmospheric nitrogen at high levels, suppress weed growth, and reduce dependence on costly nitrogen fertilizers, cowpea makes a substantial contribution to the sustainability of agricultural systems and the improvement of soil fertility in marginal environments (Abebe & Alemayehu, 2022). In Cameroon, cowpea cultivation ranks second after groundnut in the legume category (Kouam *et al*., 2017), and its seeds are used in the preparation of a dish commonly called "koki" (Mbofung *et al*., 2002). Although cowpea plays a crucial nutritional, socioeconomic, and agronomic role, its productivity remains low (Amadou *et al*., 2025) largely due to the combined effects of abiotic and biotic stress factors. Within the range of biological limitations affecting cowpea, damage caused by insect pests is the most critical, leading to major economic losses. (Amadou et *al*., 2025). Insect pests such as *Aphis crassivora*, *Megalurothrips sjostedti*, *Maruca vitrata,* and *Clavigralla tomentosicollis* that feed and/or lodge in the tissues of stems and pods or that suck plant sap, or that nibble and pierce the foliage surface, reduce the photosynthetic potential of the plants and consequently cause a drop in vegetable quality and seed yield (Mohammadou *et al*., 2023). In Cameroon, the harmful effects of synthetic insecticides have been demonstrated (Osariyekemwen and Benedicta, 2017; Dzokou *et al.,* 2020; Sopkoutie *et al*., 2024). It is therefore urgent to find solutions to fight against insect pests while preserving beneficial insects. To do this, many plants through their extracts provide natural insecticides and are environmentally friendly, breaking down naturally without leaving toxic residues that could contaminate the soil, air, or water (Wangkaqué *et al*., 2025) and can therefore be used as a substitute for synthetic insecticides (Barry *et al*., 2017; 2019). Botanical insecticides typically contain complex blends of secondary metabolites that act via multiple routes: penetration through the cuticle (contact), entry into the tracheal system (fumigant), or ingestion after systemic translocation (Padial *et al*., 2025). This is the case for: *Annona senegalensis* (Annonaceae), which was used by Vandi *et al*., 2020, in the control of cowpea flower thrips, *Eucalyptus camaldulensis* (Myrtaceae) used by Abdoulaye *et al*., 2018 and Ogunmefun *et al*., 2023, on *Callosobruchus maculatus* (Cowpea weevil), and *Chromolaena odorata* (Asteraceae) used by (Osariyekemwen and Benedicta, 2017) against the Cowpea Beetle, *Callosobruchus maculatus*. Published works on the relationships between *V. unguiculata* and insect pests in fields have been reported thanks to the work of Barry *et al.* (2017; 2019) in Adamaoua, Far North and Eastern Regions of Cameroon, respectively, where they mentioned that the major pest of cowpea was *Megalurothrips sjostedti*. Also, Mohammadou *et al*., 2023 reported that in Garoua and Ngaoundéré, the major pest of cowpea was *A. craccivora* (North) (Adamaoua) in Cameroon. Since the major insect pests of cowpea in the region are known, it is therefore important to carry out research work on the impact of identified plant extracts locally used on the entomofauna of *V. unguiculata* for their optimal management in Cameroon.

3 MATERIALS AND METHODS

3.1 Study site: This study was carried out from July to October 2023; 2024, during the rainy season in Bini - Dang, district of Ngaoundéré III, Adamaoua Region in Cameroon. The study was conducted on an experimental plot covering a total area of 1,102 m², with dimensions of 58 m in length and 19 m in width.. This plot is centered on a point whose geographic coordinates are as follows: latitude: N07°24’28.9; longitude: E013°33’30.8; altitude: 1108m.

3.2 Material: It consisted of seeds of *V. unguiculata* variety “fekem” purchased in a seed sales shop in Ngaoundéré, and fresh leaves of *A. senegalensis*, *E. camaldulensis,* and *C. odorata* collected in Dang, Ngaoundéré, during the rainy season.

3.3 Methods

3.3.1 Experimental design, sowing and weeding: From July 2023 to August 2024 using a meter tape, a rope, machetes and hoes, a plot of 1102 m² was demarcated, cleared, plowed, fenced and divided into forty-four sub-plots of 4 m long and 3.5 m wide each, separated from each other by 1m aisles, that is four (4) blocks each containing 11 subplots, making a total of 44 subplots. The field was bordered by a one-meter-wide path. The field was arranged in a complete randomized block, and the three plant extracts were applied at concentrations of 5%, 10% and 15 % each, a synthetic insecticide control (Optimal), and the untreated control, and each treatment was replicated four times. Each subplot included 6 lines of 10 pockets each, that is 60 pockets per plot, and four (4) seeds were sown per pocket. Planting of seeds was done at a spacing of 50 cm inbetween the lines and 36 cm on the lines. Weeding was carried out 14 days after sowing, and two plants were left per pocket. To do this, we used strings that we aligned horizontally and vertically, following the spacings between the lines and on the lines. At the points where the strings crossed, sowing was carried out. Seed germination began 5 days after sowing. The first weeding was done two weeks after sowing. The second weeding was carried out a month after the first.

3.3.2 Preparation and Application of extracts: Fresh leaves of *Annona senegalensis*, *Eucalyptus camaldulensis*, and *Chromolaena odorata* were regularly harvested at two-week intervals during our study period in Bini-Dang, Ngaoundéré III District, Vina Department, Adamawa Region, Cameroon. The plant-based aqueous extract was prepared following the method of (Sreekanth, 2013) 200 g, 400 g, and 600 g of each type of leaf were weighed using an electronic scale, then separately crushed using a wooden mortar and pestle before being placed in a bucket containing 4 liters of water. A 24-hour rest period was provided for the mixture. After the 24-hour rest period, the mixture undewent filtration through a 0.2 mm mesh sieve into another bucket. Each resulting solution was then transferred into sprayers for application. The aqueous extracts were sprayed using 10 gauged manual sprayers 1L capacity each. Each spray corresponds to a treatment, that is to say, Optimal, *A. senegalensis*, *E. camaldulensis* and *C. odorata*. These extracts, including the synthetic insecticide Optimal, were sprayed in the evening, at sunset (5 p.m.). Applications of extracts were initiated 14 days post-sowing and continued at fortnightly intervals until the harvest stage.

3.4 Data collection: Field observations started two weeks following the sowing period. It was repeated every 7 days and was done each time in the morning (from 5:30 a.m. to 10 a.m.). The parameters measured were the number of insect species, leaves, flowers, fruit per plant/plot and seed yield. The population of these insect pests was assessed on plants in the middle rows of each subplot. To do this, counting was done using a magnifying glass for the tiniest insects and with the naked eye for the most visible. The number of leaves, flowers and fruits per plant was evaluated by counting these parameters according to the phenology of the plant. In terms of yield, when ripe, the fruits were harvested from each plot, favoring the middle rows. The fruits were opened manually, then the weight (in kg) of the seeds was evaluated using an electronic scale. For all these measured parameters, 32/60 feet/plot were sampled.

3.5 Qualitative Phytochemical analysis of the extracts

i. **Alkaloids**
Dragendorff's Test: When the extract reacts with Dragendorff's reagent, a reddish-orange or brown precipitate forms if alkaloids are present (Badiaga, 2011).

ii. **Flavonoids**
Alkaline Reagent Test: A reaction with sodium hydroxide (NaOH) initially produces a yellow color, which then disappears upon acidification (Fankam *et al.*, 2011).

iii. **Phenols and Tannins**
Ferric Chloride ($FeCl_3$) Test: Typically gives a blue-black or greenish coloration when phenols are present (N'guessan *et al.*, 2009).

iv. **Saponins**
Froth Test: When the extract is vigorously shaken with water, the appearance of a stable froth (persistent foam of about 1–2 cm) suggests the presence of saponins. (Badiaga, 2011).

v. **Steroids & Triterpenes**
Liebermann–Burchard Test: To the chloroform extract, add a few drops of acetic anhydride, gently heat, then add concentrated H_2SO_4 along the side of the tube.

vi. **Positive result (**Fankam *et al.*, 2011).

- Steroids: bluish-green to green color.
- Triterpenes: deep red or violet color

3.5 Identification of Insect Specimens: Throughout the observation period, insects active on *V. unguiculata* were captured by hand or with an entomological net. In the field, these captured specimens were preserved in vials containing 70% ethanol. The identification of these samples was done using specialized documents (Gullan and Cranston, 2008; Biondi and D'Alessandro, 2012).

3.6 Data Analysis: Data were processed through ANOVA, descriptive statistics, Microsoft Excel 2016 software, and SPSS 27. To identify specific variations within interaction implications, Tukey's HSD was employed as a post hoc analysis. Statistical significance was defined by p-values strictly below 5%.

4 RESULTS AND DISCUSSION

4.1 Phytochemical screening of the studied plant extracts

Table 1: Phytochemical screening of aqueous extracts of *Eucalyptus camaldulensis*, *Annona senegalensis* and *Chromolaena odorata*.

Compounds	*E. camaldulensis*	*C. odorata*	*A. senegalensis*
Alkaloids	+	+	+
Flavonoids	+	-	+
Phenols and Tannins	+	-	+
Saponins	+	+	+
Steroids & Triterpenes	-	+	+

-: absence; +: presence

The phytochemical screening of the aqueous leaf extracts of *E. camaldulensis*, *C. odorata* and *A. senegalensis* indicated the presence of several bioactive compounds with insecticidal activities as seen in Table 1. Alkaloids were present in all three plant species, serving as an endogenous chemical barrier. This class of secondary metabolites is essential for plant survival, providing resistance against a variety of predators and pathogens, including both invertebrate and vertebrate herbivores, as well as parasitic flora and infectious fungi or bacteria. (Bhambhani *et al.*, 2021). Alkaloid accumulation creates a hostile biochemical environment for predators. Through diverse modes of action, these substances interfere with the health and survival of any organism attempting to consume the plant tissue (Bhambhani *et al.*, 2021). The presence of alkaloids in each extract suggests that all three extracts provided a minimum amount of insect repellent potential. Conversely, *E. camaldulensis* and *A. senegalensis* exhibited a larger range of active compounds. Both species contained flavonoids, phenols, tannins, and saponins, which are known for their deterrent, antifeedant, and toxic properties, acting on the metabolism, nervous system, and growth of different species of pests (Pereira *et al.*, 2024; Padial *et al.*, 2025). These compounds operate together in a synergistic capacity to perturb insect feeding behaviour and development. For *C. odorata*, the extract did not contain flavonoids, phenols, and tannins, which may explain its lower degree of efficacy as an insecticidal agent in the field trials (Iqbal and Poór, 2025). Positive results for steroids and triterpenes signal some opportunity as a possible anti-feedant or molting inhibitors; however, they were not in sufficient concentrations for an expected insect deterrence agent in our trials (Singh *et al.*, 2025). Consequently, based on phytochemical composition, *E. camaldulensis* and *A. senegalensis* provide stronger insecticidal potential based on the abundance of bioactive compounds, and were aligned with evidence of repulsion and mortality effects tested exponentially in our evaluation.

4.2 Inventory of insect pests and predators of *Vigna unguiculata*: A total of 12 insect pest species belonging to 6 orders and 8 families were recorded on *V. unguiculata* during the 2023 and 2024 rainy seasons. The total number of individuals increased from 2,458 in 2023 to 2,628 in 2024, indicating an increase in insect abundance, likely influenced by seasonal or environmental variation (Table 1). *Aphis craccivora* (Aphididae) was the major species in both years, accounting for 48.01% of the total population in 2023 and 40.41% in 2024. This species is known as a piercing-sucking pest, capable of causing significant yield losses through sap extraction and transmission of viral diseases (Kashyap and Reddy, 2025). Its high abundance across both seasons underscores its status as a major pest of cowpea in the region, warranting focused control strategies corroborating the results obtained by Mohammadou *et al.*, 2023. Among the Coleoptera, *Ootheca mutabilis* (Chrysomelidae) was the second major pest, increasing from 234 individuals (9.89%) in 2023 to 332 (12.6%) in 2024, reflecting a noticeable rise in its population. This defoliator poses a significant threat, particularly at the seedling and vegetative stages of cowpea development (Aghora *et al.*, 2025). Other defoliators like *Altica* sp., *Podagrica decolorata*, and *Acalymma vittatum* also showed moderate but consistent presence. Their impact, although less than *O. mutabilis*, can be additive when occurring in combination with other pests. Piercing-sucking insects such as *Bemisia tabaci*, *Anoplocnemis curvipes*, and *Tettigonia viridissima* also maintained their population density across both years. This notable increase in population density suggests its emerging importance as a pest that could potentially disrupt cowpea production if not controlled. *Coccinella septempunctata,* a predatory insect, was equally recorded, showing a sharp rise in population density from 97 (3,98 %) in 2023 to 117 (4,48 %) in 2024. Their presence is ecologically significant, making them very important effective bio-controllers as they can contribute to the natural regulation of soft-bodied pests like aphids (Altaf *et al.*, 2025), whose population density reduced from 1180 in 2023 to 1062 in 2024. The polyphagous moth *Amsacta moorei* (Erebidae) was observed in similar proportions across both years, highlighting its stable population dynamics. The leading presence of piercing-sucking insects and defoliators calls for an integrated pest management (IPM) strategy emphasizing both chemical-free botanical control, like aqueous plant extracts, and biological regulation where feasible.

Table 1: Insect pests of cowpea inventoriated in 2023 and 2024 in numbers, percentage and status.

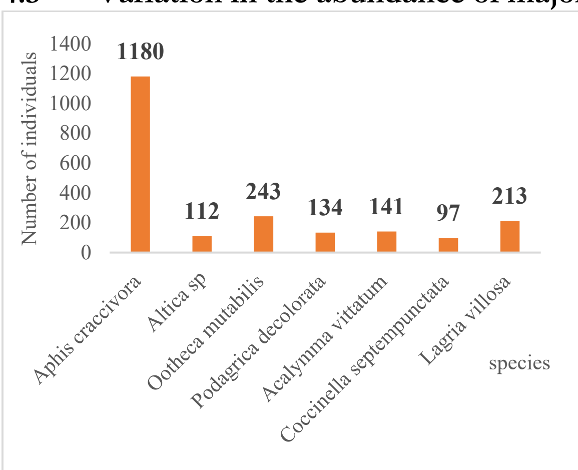
Insect pests 2023		Visits/Years					Insect pests 2024
			2023	**2024**			
Ordre	**Family**	**Genus/species**	**n**	**p%**	**n**	**p%**	**Insect status**
Coleoptera	Chrysomelidae	*Altica sp*	112	4,56	125	4,76	defoliators
		Ootheca mutabilis Sahlberg,1829	243	9,89	332	12,63	defoliators
		Podagrica decolorata Duvivier, 1892	134	5,45	171	6,51	defoliators
		Acalymma vittatum Fabricius, 1775	141	5,74	168	6,39	defoliators
	Coccinellidae	*Coccinella septempunctata* Linnaeus, 1758	97	3,95	117	4,45	Predators
	Tenebrionidae	*Lagria villosa* Fabricius, 1781	213	8,67	273	10,39	defoliators
Orthoptera	Tettigonidae	*Tettigonia viridissima* Linnaeus, 1758	65	2,64	78	2,97	piercing-sucking
Hemiptera	Aphiddae	*Aphis craccivora* Koch, 1854	1180	48,01	1062	40,41	piercing-sucking
	Aleyrodidae	*Bemisia tabaci* Gennadius, 1889	88	3,58	91	3,46	piercing-sucking
Heteroptera	Coreidae	*Anoplecnemis curvipes* Fabricius, 1781	58	2,36	67	2,55	piercing-sucking
Lepidoptera	Lymantriidae	*Lymantria dispar* Linnaeus, 1758	60	2,44	66	2,51	defoliators
	Erebidae	*Amsacta moorei* Butler, 1875	67	2,73	78	2,97	Polyphagous
			2458	**100**	**2628**	**100**	

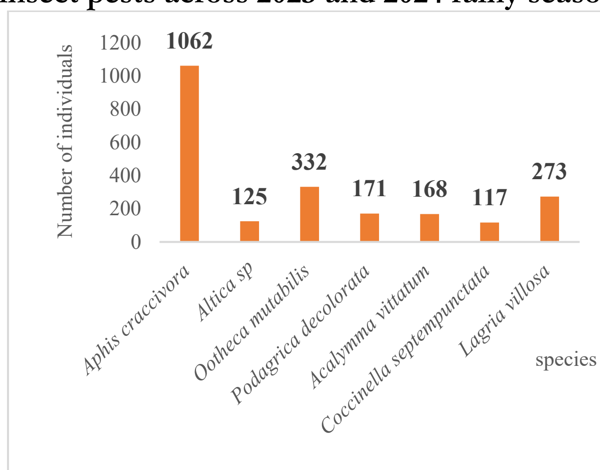
n: number of individuals; p%: percentage number of individuals, p(n/total)*100

Aphis craccivora on cowpea pods *Ootheca mutabulis* on cowpea leaves

Figure 1: Some of the insect pests captured on *Vigna unguiculata* in Ngaoundere in 223 and 2024

4.3 Variation in the abundance of major insect pests across 2023 and 2024 rainy season:





2023 **2024**

Figure 2: Variation in the abundance of major insect pests in the 2023 and 2024 rainy seasons

The variation in abundance of major insect pest species captured on *V. unguiculata* during the 2023 and 2024 rainy seasons is presented in Figure 2. Across both years, *A. craccivora* remained the most dominant pest species, with 1180 individuals recorded in 2023 and 1062 in 2024. This reduction could be due to annual fluctuations in ecological conditions, including variations in climate (rainfall and temperature) and the presence of natural enemies such as *C. septempunctata* Linnaeus, 1758, whose density increased from 97 in 2023 to 117 in 2024, which are known for regulating pest populations, especially aphids (Khanduri and Sharma, 2025). The continued dominance of *A. craccivora*, coupled with the increase in population densities of other insect pests over the 2023 and 2024 rainy seasons, emphasizes the necessity of implementing integrated pest management programs that target both established and emerging pest threats throughout successive growing seasons. Insecticidal Effect of Aqueous Leaf Extract of *Annona senegalensis*, *Eucalyptus camaldulensis*, and *Chromolaena odorata* on the population density of *Ootheca mutabulis* and *Aphis craccivora* at concentration of 5%, 10%, 15% on *Vigna unguiculata* in 2023 and 2024.

Table 2 presents the evolution of insect infestation (mean ± SEM) over time, Weeks After Sowing (WAS) following the application of aqueous plant extracts from *E.camaldulensis* (Ec), *A. senegalensis* (As), and *C. odorata* (Co), each tested at varying concentrations (5%, 10%, and 15%).

Table 2: Population density of *Ootheca mutabulis* in 2023 raining season.

Treatment	Weeks After Sowing (WAS)								*F*
	1	2	3	4	5	6	7	8	
Ec15	5,00±0,00	4,50±0,50	4,00±0,00	1,00±0,00	0,00±0,00	0,00±0,00	0,00±0,00	1,50±0,50	$8,929^{ns}$
Ec10	2,00±0,00	4,00±0,00	1,00±0,00	2,00±0,00	1,00±0,00	1,00±0,00	4,00±0,00	1,66±0,21	$7,87^{ns}$
Ec5	1,00±0,00	5,50±4,50	1,00±0,00	1,00±0,00	1,00±0,00	1,00±0,00	2,00±0,00	4,00±0,00	$0,372^{ns}$
As15	5,00±0,00	4,00±0,00	2,00±0,00	1,00±0,00	1,00±0,00	0,00±0,00	1,00±0,00	2,00±0,00	-
As10	1,00±0,00	1,00±0,00	3,00±0,00	1,50±0,50	1,00±0,00	0,00±0,00	0,00±0,00	1,00±0,00	$1,286^{ns}$
As5	3,00±2,00	2,33±1,33	4,00±0,00	1,00±0,00	2,00±1,00	1,00±0,00	1,00±0,00	1,00±0,00	$0,392^{ns}$
Co15	1,00±0,00	1,00±0,00	3,00±0,00	1,00±0,00	0,00±0,00	1,00±0,00	1,00±0,00	2,25±0,50	$1,792^{ns}$
Co10	3,00±2,00	2,50±1,50	1,50±0,50	1,33±0,33	2,00±0,00	1,00±0,00	1,00±0,00	2,00±0,00	$0,42^{ns}$
Co5	3,00±1,15	3,00±1,15	2,00±0,00	1,00±0,00	1,00±0,00	0,00±0,00	1,50±0,50	0,00±0,00	$0,466^{ns}$
Op	2,00±0,00	1,00±0,00	1,00±0,00	0,00±0,00	1,00±0,00	0,00±0,00	0,00±0,00	1,33±0,33	$0,571^{ns}$
Tm	3,33±1,52	2,00±0,40	1,00±0,00	1,50±0,50	1,00±0,00	1,00±0,00	3,66±0,33	2,25±0,64	3,636*
F()	$0,609^{ns}$	$0,55^{ns}$	9,857*	$0,533^{ns}$	$0,643^{ns}$	-	11,531***	$1,457^{ns}$	

Each value represents the mean ± SEM. According to Tukey's post hoc analysis, shared uppercase letters within a single row indicate that the differences between those means are not significant at the 5% probability level, ns = non-significant difference (P > 0.05); (P < 0.01) = highly significant difference; (P < 0.001) = Extremely significant differences were noted. The notation (–) signifies that F-values were incalculable due to the presence of equal variance within the dataset. *E.camaldulensis* (Ec), *A. senegalensis* (As), and *C. odorata* (Co)

Table 3: Population density of *Ootheca mutabulis* in 2024 raining season.

Treatment	Weeks After Sowing (WAS)								*F*
	1	2	3	4	5	6	7	8	
As5	1,00±0,00	4,50±0,50	4,00±00,00	1,00±0,00	0,00±0,00	1,00±1,00	0,00±0,00	1,50±0,50	7,550^{ns}
As10	5,00±00,00	2,66±0,66	2,00±00,00	1,00±0,00	0,00±0,00	0,00±0,00	1,00±00,00	2,00±0,00	0,092^{ns}
As15	3,00±1,15	3,00±1,15	2,00±00,00	1,00±0,00	1,00±0,00	2,33±1,33	1,50±0,50	0,00±0,00	0,330^{ns}
Ec5	1,33±0,33^{A}	1,25±0,25^{A}	1,00±00,00^{A}	1,50±0,50^{A}	1,00±0,00^{A}	1,00±0,00^{A}	3,66±0,33^{B}	0,00±0,00	12,424***
Ec10	1,00±0,00	2,50±1,50	1,50±0,50	1,33±0,33	2,00±0,00	1,00±0,00	1,00±0,00	2,00±0,00	0,982^{ns}
Ec15	2 ,00±00,00	4,00±00,00	1,00±00,00	2,00±0,00	1,00±0,00	1,00±0,00	4,00±00,00	1,66±0,33	4,270^{ns}
Co5	1,00±00,00	1,00±00,00	3,00±00,00	1,50±0,50	1,00±0,00	1,00±0,00	0,00±0,00	1,50±0,50	1,700^{ns}
Co10	3,00±2,00	2,33±1,33	4,00±00,00	1,00±0,00	2,00±1,00	1,00±0,00	1,00±0,00	1,00±0,00	1,214^{ns}
Co15	1,00±0,00	5,50±4,50	1,00±00,00	1,00±0,00	1,00±0,00	2,00±1,00	2,00±00,00	4,00±00,00	0,649^{ns}
Tm	1,00±00,00	4,75±0,25	4,50±0,50	4,00±1,00	3,00±1,54	4,00±1,52	3,33±1,20	2,33±0,33	1,861^{ns}
Op	2 ,00±00,00	1,00±00,00	1,00±00,00	0,00±0,00	1,00±0,00	0,00±0,00	3,00±0,00	1,33±0,33	2,000^{ns}
F	1,663^{ns}	1,155^{ns}	7,756**	1,819^{ns}	0,556^{ns}	0,552^{ns}	1,950^{ns}	1,538^{ns}	

Each value represents the mean ± SEM. According to Tukey's post hoc analysis, shared uppercase letters within a single row indicate that the differences between those means are not significant at the 5% probability level, ns = non-significant difference (P > 0.05); (P < 0.01) = highly significant difference; (P < 0.001) = Extremely significant differences were noted. The notation (–) signifies that F-values were incalculable due to the presence of equal variance within the dataset. *E.camaldulensis* (Ec), *A. senegalensis* (As), and *C. odorata (*Co)

Table 2 and 3 show the variation in the population density of *O. mutabilis* on *V. unguiculata* under different treatments of aqueous plant extracts after several Weeks after sowing (WAS) in 2023 and 2024 during the rainy season. In 2023, *O. mutabilis* density fluctuated over time depending on the treatment and concentration applied. *Annona senegalensis* (As10 and As15), *C. odorata* (Co15), and *E. camaldulensis* (Ec5) exhibited lower population densities of *O. mutabilis* compared to the untreated control (Tm) at multiple time points. *Eucalyptus camaldulensis* at 15% (Ec15) treatment had the highest F_0 value (8.929), though statistically non-significant (ns), suggesting limited consistent suppression across time. The untreated control (Tm) showed the highest beetle resurgence, particularly at 7 WAS (3.66 ± 0.33). with an F value of 3.636, and was statistically significant at p< 0.05, indicating a clear difference from other treatments. A significant effect of treatments was observed at 3 WAS (F = 9.857) and 7 WAS (F = 11.531), showing that the treatments had the most pronounced influence at these stages of cowpea growth. At 1, 2, 4, 5, 6, and 8 WAS, we observed a non-significant treatment effect (P > 0.05), suggesting variable effectiveness or delayed insecticidal action. A peak in *O. mutabulis* population density was observed around 7 WAS, especially in the untreated control, and a decline afterwards, which can be due to environmental factors or delayed plant defenses. In most treatments, the *O mutabulis* population density remained consistently low (1–2 individuals) or declined over time. The results obtained here lend weight to the argument that aqueous leaf extracts of *A. senegalensis*, *E. camaldulensis*, and *C. odorata* are effective in reducing *O. mutabilis* populations on cowpea, with the best control observed in As10, As15, and Ec5 treatments. The statistical differences at 3 and 7 WAS are critical, indicating periods of peak vulnerability where botanical insecticides exert their strongest influence. These findings advocate for the inclusion of botanical biopesticides within sustainable pest control frameworks for cowpea production. Whereas in 2024, insect populations generally increased around 2 and 3 WAS and sharply decreased by 4–5 WAS, possibly due to plant growth stages or treatment effects. A very low population density is seen in 6, 7, and 8 WAS, indicating effective insect suppression or low natural infestation later in the season. Subplots treated with As10 and As15 consistently show a very low insect population density, suggesting strong insecticidal effects. On the other hand, Ec15 shows variable suppression but had one of the highest population densities on 3 WAS (8.00 ± 1.00), raising concerns about its consistency. As for Tm (untreated control) and Co5 often have higher insect population density, particularly early on (2 WAS and 3 WAS), confirming that insect infestation naturally occurs in the absence of treatment. A highly significant difference is observed on 3 WAS (F = 7.756**) and 4 WAS (F = 1.819ns), which suggests a strong treatment effect, especially at 3 WAS. On 5, 6, 7, and 8 WAS, F-values are non-significant, which might be due to very low insect populations, reducing statistical variability. The most highly significant difference is observed in the overall treatment means (F = 12.424***), indicating that treatments had a statistically strong influence in reducing the population density of *Ootheca mutabulis*. Across the 2023 and 2024 rainy seasons, the untreated control plots exhibited clear infestation peaks of *Ootheca mutabilis* during the vegetative stage of cowpea, with the largest increases in population density were observed at 3 weeks after sowing (WAS) and a secondary rise by 7–8 WAS. These peaks indicate that the crop's early vegetative stage is the most vulnerable period for *O. mutabilis* attack (Halerimana *et al.*, 2022). In contrast, plots treated with aqueous plant extracts maintained substantially lower beetle densities throughout the sampling period. The three botanical species tested, *Eucalyptus camaldulensis* (Ec), *Annona senegalensis* (As), and *Chromolaena odorata* (Co), reduced *O. mutabilis* numbers relative to the untreated control in both years, demonstrating consistent suppressive effects across seasons. Such efficacy of locally available plant extracts is consistent with the growing body of work reporting biopesticides as viable alternatives to synthetic insecticides (Ayilara *et al.*, 2023).

4.4 Most efficient concentrations: Analysis of weekly densities shows that certain concentrations consistently outperformed others:

- *Eucalyptus camaldulensis* 5% (Ec5): Ec5 produced one of the most stable and lowest beetle densities across weeks, with near-complete suppression after the first week in both seasons. These findings suggest that a comparatively minimal concentration of *E. camaldulensis* extract can be highly effective, likely because Eucalyptus leaves contain volatile terpenoids (e.g., eucalyptol) and other compounds with repellent/antifeedant activities (Danna *et al.*,2024).
- *Annona senegalensis* 10–15% (As10, As15): Higher concentrations of *A. senegalensis* 10-15%) showed robust and sustained suppression of *O. mutabilis*, often reducing counts to near zero by 4–5 WAS. This result concords with phytochemical evidence that *Annona* species contain biologically active acetogenins and alkaloids that can act as feeding deterrents and toxicants at sufficient doses (Akah, 2023).
- *Chromolaena odorata* 10-15% (Co10, Co15): *C. odorata* at 10-15% likewise gave strong suppression relative to 5% treatments. The superior performance at 10–15% aligns with recent reports of *C. odorata* extracts exhibiting insecticidal and antifeedant properties against several coleopteran and lepidopteran pests when applied at effective concentrations (Seni *et al.*, 2025).

Table 4: Population density of *Aphis craccivora* in 2023.

Traitement	Weeks After Sowing (WAS)								*F()*
	1	2	3	4	5	6	7	8	
Ec15	0,00±0,00	15,00±5,00	0,00±0,00	2,00±0,00	4,00±0,00	0,00±0,00	0,00±0,00	5,00±0,00	2,544^{ns}
Ec10	0,00±0,00	0,00±0,00	2,00±0,00	0,00±0,00	0,00±0,00	5,00±0,00	5,00±0,00	2,00±0,00	-
Ec5	5,00±0,00	5,00±0,00	2,00±0,00	15,00±0,00	1,00±0,00	0,00±0,00	0,00±0,00	1,00±0,00	-
Co15	0,00±0,00	50,00±0,00	0,00±0,00	0,00±0,00	6,00±4,00	0,00±0,00	4,50±0,50	5,00±0,00	34,356^{ns}
Co10	0,00±0,00	52,50±2,50	5,00±0,00	0,00±0,00	0,00±0,00	0,00±0,00	0,00±0,00	0,00±0,00	120,33*
Co5	0,00±0,00	52,50±47,50	2,00±0,00	10,00±0,00	0,00±0,00	0,00±0,00	2,00±0,00	2,00±0,00	0,384^{ns}
As15	2,00±0,00	0,00±0,00	0,00±0,00	0,00±0,00	5,00±0,00	0,00±0,00	0,00±0,00	0,00±0,00	-
As10	0,00±0,00	0,00±0,00	2,00±0,00	20,00±0,00	12,50±7,50	4,00±0,00	0,00±0,00	0,00±0,00	0,629^{ns}
As5	5,00±0,00	40,00±10,00	0,00±0,00	20,00±0,00	0,00±0,00	0,00±0,00	12,50±0,00	5,00±0,00	3,197^{ns}
Op	7,50±2,50	0,00±0,00	10,00±0,00	0,00±0,00	0,00±0,00	5,00±0,00	10,00±0,00	0,00±0,00	0,467^{ns}
Tm	5,00±0,00	48,33±26,19	5,50±4,50	75,00±25,00	25,00±0,00	75,00±25,00	22,50±0,00	20,00±0,00	1,321^{ns}
F()	0,417^{ns}	0,383^{ns}	0,506^{ns}	2,044^{ns}	1,117^{ns}	1,583^{ns}	11,071*	-	

Each value represents the mean ± SEM. According to Tukey's post hoc analysis, shared uppercase letters within a single row indicate that the differences between those means are not significant at the 5% probability level, ns = non-significant difference ($P > 0.05$); ($P < 0.01$) = highly significant difference; ($P < 0.001$) = Extremely significant differences were noted. The notation (–) signifies that F-values were incalculable due to the presence of equal variance within the dataset. *E.camaldulensis* (Ec), *A. senegalensis* (As), and *C. odorata* (Co)

Table 5: Population density of *Aphis craccivora* in 2024

Traitement	Weeks After Sowing (WAS)								F_0
	1	2	3	4	5	6	7	8	
As5	0,00±0,00	15,0±5,00	0,00±0,00	2,00±0,00	4,00±0,00	1,00±0,00	0,00±0,00	5,00±0,00	2,234^{ns}
As10	1,50±0,50	0,00±0,00	0,00±00,00	0,00±0,00	5,00±0,00	0,00±0,00	0,00±0,00	0,00±0,00	16,333^{ns}
As15	1,00±1,15	27,50±22,50	2,00±00,00	10,00±0,00	0,00±0,00	0,00±0,00	2,00±000	2,00±0,00	0,373^{ns}
Ec5	5,00±,33	50,00±0,00	5,50±4,50	10,0±0,50	25,0±0,00	0,00±0,00	0,00±0,00	0,00±0,00	20,375*
Ec10	0,00±0,00	52,50±2,50	5,00±00,00	0,00±0,33	0,00±0,00	0,00±0,00	0,00±0,00	5,00±0,00	90,25^{ns}
Ec15	0,00±0,00	0,00±0,00	2,00±00,00	0,00±0,00	0,00±0,00	5,00±0,00	5,00±0,00	2,00±0,00	-
Co5	0,00±0,00	0,00±0,00	2,00±00,00	20,0±0,00	0,00±0,00	4,00±0,00	0,00±0,00	0,00±0,00	-
Co10	5,00±2,00	40,0±10,0	0,00±00,00	20,00±0,00	0,00±1,00	0,00±0,00	12,50±2,50	5,00±0,00	3,214^{ns}
Co15	5,00±0,00	5,00±00,00	2,00±00,00	15,00±0,00	1,00±0,00	2,00±0,00	0,00±0,00	1,00±0,00	-
Tm	10,00±0,00	27,0±23,0	100,00±0,00	20,0±0,00	9,25±3,94	12,50±7,50	50,66±28,29	16,66±6,00	1,883^{ns}
Op	5,00±00,00	0,00±0,00	15,00±0,50	0,00±0,00	0,00±0,00	5,00±0,00	10,00±0,00	0,00±0,00	1,611^{ns}
F_0	41,00*	0,960^{ns}	39,510**	-	1,451^{ns}	0,234^{ns}	0,536^{ns}	0,956^{ns}	

Each value represents the mean ± SEM. According to Tukey's post hoc analysis, shared uppercase letters within a single row indicate that the differences between those means are not significant at the 5% probability level, ns = non-significant difference (P > 0.05); (P < 0.01) = highly significant difference; (P < 0.001) = Extremely significant differences were noted. The notation (–) signifies that F-values were incalculable due to the presence of equal variance within the dataset. *E.camaldulensis* (Ec), *A. senegalensis* (As), and *C. odorata* (Co)

Tables 4 and 5 show the variation in the population density of *Aphis craccivora* on *Vigna unguiculata* under different treatments of aqueous plant extracts after several days after sowing (WAS) in 2023 and 2024 during the rainy season.

In 2023, *Aphis craccivora* populations fluctuated significantly across treatments and over time in both 2023 and 2024. Aphid populations were most abundant in the untreated plots (Tm), with peak values of 75.00 ± 25.00 at 4 Weeks after sowing (WAS) and 48.33 ± 26.19 at 2 WAS. *Chromolaena odorata* at 15% (Co15) and 10% (Co10) also recorded high aphid population density, exhibiting reduced effectiveness. *Annona senegalensis* at 10% (As10) and 15% (As15) recorded no aphid presence across all dates, reflecting outstanding control performance. *Eucalyptus camaldulensis* at 5% (Ec5) had moderate aphid population density at certain dates (4 WAS), exhibiting a partial suppression. The highest F-value was observed at 7 WAS (F = 11.071*), demonstrating pronounced treatment effects during the initial phase of crop development. Statistical significance was absent across most F-value assessments (P > 0.05) at other dates, possibly due to variability in infestation onset or fluctuating aphid pressure.Whereas in 2024, Aphid populations increased early (especially at 1 and 2 WAS), which was followed by a reduction in population levels after 4 WAS. The untreated control (Tm) exhibited high population levels at 7 WAS (50.66 ± 28.29), emphasizing its position as a reference treatment. *Annona senegalensis* (As10, As15) demonstrated persistent control efficacy, as evidenced by low aphid counts across the season. *Eucalyptus camaldulensis* at 5% (Ec5) showed better efficacy in 2024, with a significant F = 20.375*, maintaining aphid population density low. *Chromolaena odorata* at 10% (Co10) in 2024 equally showed very poor efficacy with high aphid densities at 4 WAS. The highest treatment effects were observed at 1 WAS (F = 41.00*) and 3 DAS (F = 39.51**), emphasizing the necessity for proactive measures during the initial stages. *Annona senegalensis* at 10% and 15% proved to be the most efficacious and reliable botanical treatment across both seasons, achieving near-total suppression of *Aphis craccivora*. Improved control was observed with *Eucalyptus camaldulensis* at 5% in 2024, mainly at crucial early stages. *Chromolaena odorata* (particularly at 10%) and the untreated controls consistently exhibited high aphid population densities, underlining their low efficacy. Intervention is most vital in the early post-sowing period (1 to 3 WAS), corresponding to the peak of aphid infestation and when treatments yield the strongest results. Across the 2023 and 2024 rainy seasons, the untreated control plots (Tm) consistently showed severe infestations of *Aphis craccivora*, with marked peaks occurring between 3–5 WAS in 2023 and slightly later (5–7 WAS) in 2024. These peaks coincide with the cowpea's flowering and early podding stages, which are known to be highly susceptible to aphid attack due to increased nutrient flow in plant tissues (Aliyu *et al.*, 2023). The high and recurrent densities in control plots underline the pest status of *A. craccivora* and the risk of yield loss in the absence of protection. By contrast, all plots treated with aqueous plant extracts exhibited substantially lower aphid densities across both years. The three species tested, *Eucalyptus camaldulensis* (Ec), *Annona senegalensis* (As), and *Chromolaena odorata* (Co), consistently reduced aphid populations relative to the untreated control, demonstrating reproducible bioinsecticidal effects. This supports a growing body of evidence that botanical insecticides can provide sustainable alternatives to synthetic chemicals in legume protection (Kutullo *et al.*, 2024).

4.5 Most efficient concentrations: Analysis of the temporal population dynamics highlights that specific concentrations achieved the most consistent suppression of *A. craccivora*:

- *Eucalyptus camaldulensis* 15% (Ec15):

Ec15 maintained aphid densities near zero across all weeks in both years, confirming its strong and reliable suppressive effect. The efficacy of *Eucalyptus* extracts is supported by Kalaivani *et al.*, 2025, whose research hihlights the potent insecticidal activity of eucalyptus oil against *S. derogata*, demonstrating its efficacy in reducing larval weight, increasing developmental duration, and inducing high mortality rates, particularly in early instars. These findings reinforce the potential of *Eucalyptus camaldulensis* as an alternative to synthetic pesticides for sustainable pest

- *Annona senegalensis* 15% (As15):

Higher concentrations of *A. senegalensis* (15%) provided robust suppression, with aphid populations collapsing after initial colonization. This aligns with J. Ruiz Hidalgo *et al.*, 2018 who showed that natural acetogenins in the Annonaceae family are promising metabolites for insect control. Chemical modification of these substances through derivatization mitigates their toxic impact on larvae in the early stages of development of *Spodoptera frugiperda* Smith (Lepidoptera: Noctuidae).

- *Chromolaena odorata* 15% (Co15):

Co15 also suppressed aphid populations effectively across weeks, outperforming lower concentrations (5–10%). Comparable outcomes have been described in the work of (Nurhayati and Haryadi, (2022), where C. *odorata* extracts significantly reduced *Aphis gossypii* on Chili Plants.

CONCLUSION

This work contributes to the effectiveness of botanical insecticides on the insect fauna of *V. unguiculata* for their optimal management. The results from two consecutive rainy seasons demonstrated that untreated cowpea plots are highly vulnerable to early and mid-season infestations of *Ootheca mutabilis* and *Aphis craccivora*, leading to severe pest pressure during critical growth stages. In contrast, aqueous extracts of *Eucalyptus camaldulensis*, *Annona senegalensis*, and *Chromolaena odorata* consistently suppressed pest populations, with concentration-dependent effects. The most efficient treatments were Ec5 for *O. mutabilis* and 15% concentrations of As and Co for both pests, as well as Ec15 for aphids. These findings corroborate recent reports on the bioinsecticidal potential of these plants and confirm their value as eco-friendly alternatives to synthetic insecticides. Integrating such botanicals into cowpea pest management programs can contribute to sustainable crop protection, reduced reliance on synthetic chemicals, and improved food security in smallholder farming systems.

ACKNOWLEDGEMENTS

The authors are grateful to all those who, in one way or the other, contributed to the achievement of this work. The experimental plot was graciously offered by Pr. Adamou Moïse.

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