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Insecticidal Effect of the Essential Oil of *Eucalyptus globulus* Leaves on the Aphid, *Aphis craccivora* (Homoptera: Aphididae) of *Vigna unguiculata* in Central Region of Togo

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ABSTRACT

Background: *Vigna unguiculata* (L.) Walp. is an important vital crop in the diet of populations, whose productivity is declining due to the pressure of pests, including *Aphis cracivora* Koch (Homoptera: Aphididae). To combat these pests, farmers use synthetic chemical products, which are highly toxic to human health and useful entomofauna. To remedy these problems and find alternative to these synthetic chemical pesticides, this study aims to evaluate the efficacy of a formulation based on the essential oil of *E. globulus* on *A. craccivora*.

Methods: The test was realised in the field using the Fischer experimental design with five replicates. Each replicate consisted of three treatments with the *E. globulus* essential oil formulation at different concentrations (0.1, 0.5 and 1%), a positive control (treatment with the synthetic insecticide K-optimal (Acetamiprid-Lamdacyhalothrin)) and an untreated plot. *A. craccivora* population dynamics and pod yield were the parameters evaluated during the experimentation.

Result: The essential oil of *E. globulus* formulation, at a concentration of 1% reduced considerably the density of *A. craccivora* population (4.8±0.12 aphids per plant) and induce a higher yield in terms of number of pods (12.42±1.16 pods per plant) compared to the untreated plot (48.2±1.02 aphids per plant; 6.325±0.33 pods per plant). Statistical analysis showed that the effect of the formulation based on 1% of *E. globulus* essential oil was similar to the synthetic insecticide effect.

Key words: *Aphis craccivora*, Biopesticide, Essential oil, *Eucalyptus globulus*.

INTRODUCTION

Vigna unguiculata (L.) is a widely grown legume with major production in West Africa (Kim *et al.*, 2025). Countries such as Nigeria, Niger, Burkina-Faso and Ghana are the major producers which has an average yield of 0.87 t/ha (FAO, 2025). The seeds of *Vigna unguiculata* contain a high protein content (19-35%), very rich in lysine and tryptophan, two essential amino acids (Ibro *et al.*, 2014). It helps reduce malnutrition and also contributes to increase the income of smallholders (Gomes *et al.*, 2019; Manda *et al.*, 2020; Vaishna *et al.*, 2025).

Despite its importance in Togolese farming systems, *Vigna unguiculata* yields remain low, fluctuating between 0.2 and 0.45 t/ha (DSID, 2017). This, due to high pressure of pest, including aphids which negatively affect yields and the nutritional quality of the seeds; aphids feed by sucking the sap from the plant, which causes the slowdown of plant growth, the curling and premature fall of leaves, a reduction in the number of pods and seeds and a reduction in seed size (Akello and Sikora, 2012). They also transmit certain phytoviruses.

Most farmers use synthetic chemical pesticides to control these pests. Studies have shown that these products are highly toxic to humans and the environment. They are persistent in the environment and destroy useful entomofauna. Other studies have shown that aphids develop resistance to these synthetic chemical insecticides (Bonnemain and Chollet, 2003; Harris, 2003). In this situation, it is important to adopt a biological control approach. Several studies have demonstrated the insecticidal efficacy of plant extracts (Adesina and Enudeme, 2018; Akantetou *et al.*, 2021; Mario *et al.*, 2021; Labdelli *et al.*, 2022; Nadio *et al.*, 2023). These extracts, especially essential oils contain a cocktail of biomolecules, which are less persistent in the environment, less toxic and can solve the problem of resistance. In the context of

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these findings, we hypothesised that phytosanitary treatment of *Vigna unguiculata* crop with a formulation based on the essential oil of *Eucalyptus globulus* would lead to a reduction of the population of *A. craccivora* aphids and promote good production. *E. globulus* is an indigenous plant from Togo that has for a long time been considered as a medicinal plant, whose extracts are used for the treatment of respiratory tract infections (Gbekley *et al.*, 2017; Sharma *et al.*, 2021; Ghedira, 2025). Knowledge of its chemical composition has led researchers to explore its effectiveness on crop pests. In Togo, the effectiveness of its essential oil has been tested on several insect pests, namely the cotton pests *Pectinophora gossypiella* S. and *Thaumatotibia leucotreta* M. (Lepidoptera) (Nadio *et al.*, 2023) and on post-harvest pests of corn *Sitophilus zeamais* Motsch and *Tribolium castaneum* Herbst. (bokobana *et al.*, 2022). However, its effectiveness has never been tested on aphids *A. craccivora* in cowpea crops in Togo.The aim of our work is, therefore, to evaluate the aphicidal efficacy of the essential oil of *E. globulus* Labill. leaves on the aphid *A. craccivora* Koch (Homoptera: Aphididae).

MATERIALS AND METHODS

Experimental site

The experimentation was set up at the agro-ecological station of Tchébébé in central region of Togo. Its geographical coordinates are: N: 8.42325° and E: 0.98107°. This site has a semi-humid tropical climate of the Sudanian type with a monomodal rainfall pattern characterised by two seasons: a rainy season from April to October and a dry season from November to March. Annual rainfall in the year of the experimentation (2023) is approximately 1390.2 mm.

Experimental design

The experimentation was conducted on *V. unguiculata*, Vitoco variety. The experimental design was the randomized complete block design with five replicates. Each replicate consisted of five objects corresponding to the different treatments. Each treatment covered four ridges and was separated from one other by two other ridges that were used as a barrier to prevent insecticides passing from one treatment to another during spraying. Each ridge was 5 m long. The following treatments were carried out:

- Control (no pesticide treatment (T0).
- Treatment with *E. globulus* essential oil at a concentration of 0.1% (T1).
- Treatment with *E. globulus* essential oil at a concentration of 0.5% (T2).
- Treatment with essential oil of *E. globulus* at a concentration of 1% (T3).
- Treatment with the synthetic chemical insecticide K-optimal (Acetamiprid-Lamdacyhalothrin) at a dose of 1 L/ha (T4);

The sowing scheme adopted was 40 cm between seed hole and 50 cm between ridges. The sowing rate adopted was 2 seeds per hole. Biopesticide treatments were carried out once a week from the 15th day after emergence. These treatments were stopped one week before harvesting.

The synthetic chemical insecticide was applied twice according to what is recommended by the agriculture technical services: the first application was done 15 days after emergence and the second when the flower buds appeared. It was bought in a SPROCA store in Togo.

Two liters of each formulation were applied on 7.5 m^2 area for every treatment.

Biopesticide formulation

Formulations were carried out by mixing *E. globulus* essential oil with a solution of potassium palmitate in proportions of 75% and 25% (v/v), respectively. The essential oil of *E. globulus* used is obtained from the leaves; it contains p-Cymene (23.38%), D-Limonene (12.16%), l,8-cineole (24.47%) and ã- Terpinene (29.91%) as the major compounds (Bokobana *et al.*, 2022). The 5% concentration of potassium palmitate solution was used as an emulsifier to facilitate dilution with water and ensure stable emulsions.Table 1 illustrates the composition of 2 liters of biopesticide solution sprayed on an elementary plot measuring 7.5 m^2.

Observation and data collection

Aphids were identified using the identification keys of Blackman and Eastop (2000). Data collection consisted of:

- Weekly counts (once a week) of larvae and adults of *A. craccivora* on ten (10) randomly selected plants of each treatment, which were marked. On each plant selected and marked, aphids were counted on the five (5) subterminal leaves (Denéchère, 1981) and before the phytosanitary treatments. When larvae were present on the leaves, a 4.9 cm^2 magnifying glass was used for observation. Data collection began on the 15th day after emergence of plant.
- Counting the number of pods on ten plants selected previously per treatment at the harvest period.

Statistical analysis

The results obtained were analysed using XLSTAT version 2021.2 software. The results were analyzed using the

Table 1: Composition of 2 L of biopesticides solution sprayed.

	Treatment T1	Treatment T2	Treatment T3
E. globulus essential oil concentration	0.1%	0.5%	1%
Quantity of *E. globulus* essential oil	2 ml	10 ml	20 ml
Quantity of potassium palmitate 5%	0.67 ml	3.33 ml	6.67 ml

analysis of variance (ANOVA) procedure and the treatment means were compared by Duncan test at the 0.05 probability level. The curves and histograms were drawn using Excel.

RESULTS AND DISCUSSION

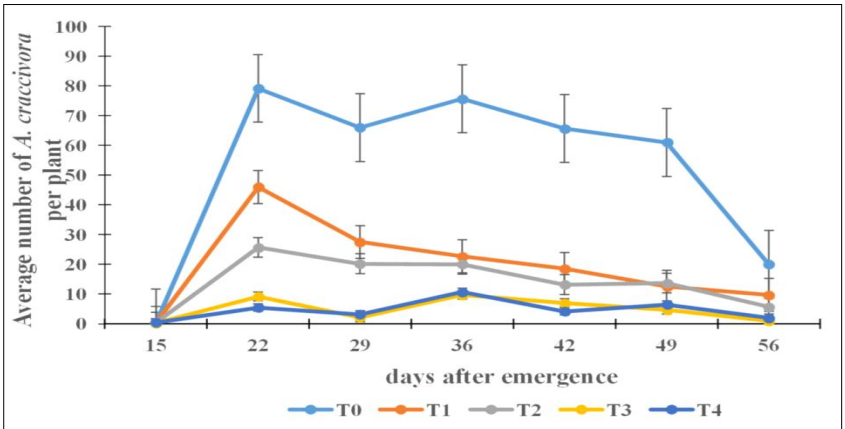
Effect of treatments on dynamic of *A. craccivora* population

Firstly, the period from 15 to 22 days after emergence is characterised initially by an increase of aphid numbers in each plot, with a higher level in the control plot (79.2 aphids per plant). From 22 to 56 days after emergence, we noted generally a decrease in aphid numbers in all treatments, despite the up-and-down variations of average number of these aphids before 56 days after emergence (Fig 1).

The average numbers of *A. craccivora* per plant during the experimentation are shown by Fig 2.

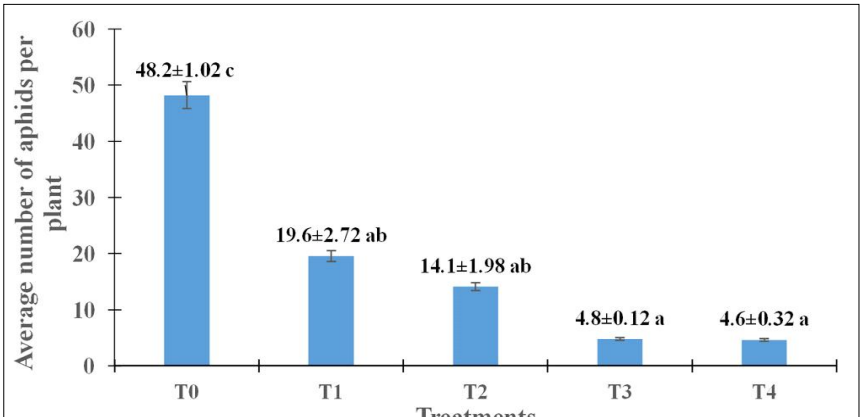
Discrimination of the means using Duncan's test at the 5% threshold shows 3 homogeneous groups, revealing a significant difference between the results obtained. The analysis shows that the average numbers of aphids per plant obtained in treatments T3 and T4 are statistically identical to each other, but statistically different from the average numbers of aphids obtained in the other treatments.

The formulation became increasingly effective in reducing the *A. craccivora* population density as the essential oil concentration increased. A high concentration of *E. globulus* essential oil implies the presence of an important quantity of active molecules to which the target insects are sensitive, thus increasing the efficacy of the bioinsecticide; these biomolecules, mostly monoterpenes such as p-Cymene, D-Limonene, l,8-cineole and γ-Terpinene (Bokobana *et al.*, 2022) have a neurotoxic effect; they interfere with the neuromodulator octopamine and GABA chloride channels (Priestley *et al.*, 2003; Jankowska



T0: Control (no pesticide treatment); T1: Treatment with *E. globulus* essential oil at a concentration of 0.1%; T2: Treatment with *E. globulus* essential oil at a concentration of 0.5%; T3: Treatment with essential oil of *E. globulus* at a concentration of 1%; T4: Treatment with the synthetic chemical insecticide K-optimal (Acetamiprid-Lamdacyhalothrin) at a dose of 1 L/ha.

Fig 1: *A. craccivora* population dynamics depending on different treatments.



Numbers with the same letter are statistically identical (p>0.05).

Fig 2: Average number of aphids per plant depending on different treatments.

et al., 2018). The effect of treatments on these pests would depend on the nature of the insecticide and its active ingredient concentration. In the case of our study, the synthetic chemical insecticide (K-optimal (Acetamiprid-Lamdacyhalothrin) and the bioinsecticide at a concentration of 1% (T3) reduced significantly the population density of *A. craccivora* compared to the control. In general, bioinsecticides based on the essential oil of plant are less persistent than synthetic chemical insecticides due to the highly volatile nature of the active ingredients they contain (Isman, 2008; Mehinto *et al.*, 2015). The reduction of the population density of *A. craccivora* by this formulation would be effected by an insect repellent and insecticidal action of the different substances tested.

Effect of different treatments on pod yields

Discrimination of means using Duncan's test at the 5% threshold reveals two homogeneous groups. Analysis of these homogeneous groups shows that there are no significant differences between the average number of pods obtained in treatments T0 and T1; nor between the average number of pods obtained in treatments T2, T3 and T4, which represent the highest numbers (Table 2).

An increase of cowpea pod production compared with the control was obtained in relation to the essential oil concentration increase. The highest mean number of pods was obtained in plots treated with the synthetic chemical insecticide and the biopesticide formulation at concentrations of 0.5% and 1%. The average number of pods obtained in plots treated with the synthetic chemical insecticide (14.4±0.8) was statistically identical to the numbers obtained in plots treated with the 0.5% and 1% concentration formulations (12.4±1.4 and 12.425±1.16, respectively). According to Vaissayre and Cauquil (2000), a low density of biting-sucking insects on plant reduces the quantity of sap ingested and the transmission of viruses. Insecticide treatments, by reducing the aphid population density on plant, therefore ensure good growth and pod productivity.

Pesticide formulations based on essential plant oils are potential alternatives to synthetic chemical pesticides. This study reports for the first time the efficacy of a pesticidal formulation based on the essential oil of *E. globulus* in the protection of cowpea crops against *A. craccivora*. *E. globulus* essential oil has most often been used in the formulation of pharmaceutical products in the medical field (Singh *et al.*, 2021; Majeed *et al.*, 2024); but nowadays there are also formulations based on *E. globulus* extracts used in plant protection. This is the case of a natural formulation used to combat potato mildew (Picaud, 2019).

Table 2: Average number of pod per plant.

Treatments	Average number of pod per plant (Nb±SE)
T0	6.325±0.33^{b*}
T1	8.6±1.24^{b}
T2	12.4±1.4^{a*}
T3	12.425±1.16^{a}
T4	14.4±0.8^{a}

*Numbers with the same letter are statistically identical (p>0.05).

There are biopesticides based on plant extracts which are also effective against *Aphis craccivora* aphids on cowpeas. This concerns two Wettable Powder formulation based on *Polygonum hydropiper* flowers and *Nicotiana tabacum* leaves; these formulations have shown more than 65% effectiveness against these aphids (Gosh, 2024).

Studies have revealed the pesticidal properties of formulations based on other botanical extracts from tropical flora against crop pests (Bambara and Tiemtoré, 2008; Ramadass and Thiagarajan, 2021; Semako *et al.*, 2021; Sane, 2021); among the plant species used for formulation, the use of *Azadirachta indica* organs appears to be one of the most popular (Adhikari *et al.,* 2020).

It's important to note that the use of plant extracts over large areas can lead to massive destruction of the plants, so it's important to plan for their replacement or replanting.

CONCLUSION

The aim of this study was to reduce the use of synthetic chemical pesticides by promoting the use of biopesticides in the management of the main pests of cowpea (*V. unguiculata*), such as *A. craccivora*. The results obtained showed that the toxicity of the essential oil is depending on concentration. Treatment with the synthetic chemical insecticide showed comparable effects with the high concentration of bioinsecticide. The high concentration formulation of *E. globulus* essential oil reduced considerably aphid population density per plant compared to the control and improved pod production. *E. globulus* essential oil can therefore be used as an active raw material in the formulation of biopesticides. One problem still to be resolved with bioinsecticides based on essential oil is their high volatility. It would therefore be necessary to develop strategies to resolve these problems for more sustained protection of the environment while ensuring high crop productivity.

Disclaimers

The views and conclusions expressed in this article are solely those of the authors and do not necessarily represent the views of their affiliated institutions. The authors are responsible for the accuracy and completeness of the information provided, but do not accept any liability for any direct or indirect losses resulting from the use of this content.

Conflicts of interest

All authors declare that they have no conflict of interest.

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