Original Research Article

Comparative Efficacy of *Ocimumbasilicum* and *Ocimumgratissimum* Essential Oils Against *Cyclaspuncticollis* Infesting Sweet Potatoes in Burkina Faso.

ABSTRACT

Aims: The aim of the present study was to compare the insecticidal effect of the essential oils *Ocimumbasilicum* and *Ocimumgratisiimum* on the sweet potato weevil *Cyclaspunticollis.*
Study design: The aim of this approach was to contribute to the management of the sweet potato weevil in Burkina Faso.
Place and Duration of Study: The experiments were carried out at the INERA Entomology laboratory in Bobo-Dioulassoduring the cropping season 2022-2023.
Methodology: Five essential oil concentrations (25; 50; 75; 100 and 125 µL/L) were used. Toxicity tests were carried out by fumigation in jars by depositing a charge of essential oil on a 6 cm disc of filter paper. Batches of ten *C. puncticollis*adults were introduced into the jars containing a fresh, healthy tuberous root of the sweet potato and immediately closed. Each test was repeated five times. The number of dead insects in each batch (treated and untreated jars) was counted every 30 min up to 5 h of exposure and for 4 days (24 h, 48 h ,72 h and 96h) per observation.
Results: The results showed that the different oils had an insecticidal effect on *C.puncticollis* and that these oils contained chemical substances responsible for the mortality observed. Indeed, mortality rates of 100% were observed after 2 hours of exposure of the weevils with the 125µL/L concentration of *O. gratissimum*, followed by concentrations of 100µL/L, 75µL/L, 50µL/L after 24 hours and 48 hours with 25µL/L. With *O. basilicum* essential oil, 100% mortality was observed after 24 hours of weevil exposure with *O.basilicum* concentrations of 125µL/L and 100µL/L, followed by 98% mortality with concentrations of 75µL/L, 50µL/L and 25µL/L after 96 hours.
Conclusion: These results suggest that the essential oils of *Ocimungratissimun* and *Ocimunbasilicum* can be used in the management of *C. puncticollis*. However, it would be necessary to carry out a concrete application of these oil extracts on large potato stocks in order to confirm or not their efficacy.

*Keywords:*oil, essential, weevils, sweet, potato

1. INTRODUCTION

In Burkina Faso, sweet potato (*Ipomea batata* (L)) is the main tuber crop produced, ahead of yam and potato (DGESS, 2022). Production takes place in almost all areas of the country, but the largest production areas are in the provinces of Sissili and Nahouri, in the south of

the country, and in the province of Kénédougou in the south-west (DGESS, 2022). Most of the varieties produced are white-fleshed, but orange-fleshed sweet potato varieties are increasingly being offered to growers. They are rich in βcarotenoids, a precursor of vitamin A. They are a means of combating vitamin A deficiency, which in Burkina Faso affects children under 5. Sweet potato production in Burkina Faso felt from 167,550 tons in 2013 (DGESS,2014) to 114,925 tons in 2021 (DGESS,2022). This drop in production could be explained mainly by soil poverty, insufficient water, diseases, climatic hazards, edaphic conditions, and insect pests (Alghali et al., 1994, Okonya et al., 2014). The sweet potato weevil species *Cylas puncticollis*Boheman has been identified as the main pest of sweet potato tuberous roots (Koussoubé et al., 2018). This species exerts strong pressure on both the crop and the tuberous roots. Sweet potato cultivation is by nature seasonal. It is therefore necessary to store the harvest in order to make it available to consumers at the right time. As the crop is not normally processed, it is the whole roots, which may contain 60 to 80% water, that are stored throughout the period prior to marketing or self-consumption. Losses of tuberous roots can reach 100%, depending on the sweet potato variety, during storage (Baimey et al., 2017). By allowing the eggs of the insect pest to remain inside the tuberized roots, the larvae develop by digging holes, resulting in huge losses to production and consequently reduced income for growers. Growers are powerless to cope with the damage caused by this pest to post-harvest roots, as control methods are essentially based on indigenous practices and the use of chemical insecticides. The growing popularity of organic production lines has led to an interest in non-chemical disinfection treatments, as the use of chemicals for insect management has become problematic (FAO, 2015). The search for alternative methods of protecting stored sweetpotato tuberous roots through the use of plant extracts such as essential oils with insecticidal effect is promising in the management of sweetpotato weevil. In recent years, numerous studies have highlighted the insecticidal and insect-repellent potential of essential oils from a number of aromatic plants (Bouzouita et al., 2008; Camara, 2009; Mostafa et al., 2014; Kanko et al., 2017; Asmae et al., 2018). Essential oils and their constituents are biologically active by direct contact or sprinkling with a very diverse spectrum of action (Cissokho et al., 2015; Asmae et al., 2018). *Ocimumbasilicum* and*O.graticimum* oils have been selected to assess their insecticidal properties as part of the search for alternatives to chemical control. The objective of this study was to evaluate the insecticidal effect by fumigation of essential oils of *O.basilicum* and *O.graticimum* on *C. puncticollis*Boheman, the main sweet potato insect pest.

2. MATERIAL AND METHODS

2.1.1 Study site

The experiments were carried out at the INERA Entomology Laboratory in Bobo-Dioulasso. In the laboratory, the mean temperature was 29.43 ± 2.71°C and relative humidity 67.64 ± 5.36%.

2.1.2 Plant material

The aerial parts of *O.gratissimun* and *O.basilicum* were harvested. The white-fleshed tuberous roots of the Djankani variety of sweet potato used for efficacy testing came from a crop planted at Bama, a town located 30 km North-West of Bobo-Dioulasso.

2.1.3 Animal material

The adult sweet potato weevil *C.puncticollis*Boheman was used for the biological tests. The populations used were derived from mass rearing in the laboratory.

2.1.4. Laboratory equipment

The following equipment was used in the laboratory:

- a 50 ml test tube was used to measure the quantities of the various solutions
- muslin cloth (5mm) to cover the plastic tubs containing the attacked potatoes.
- glass bottles for testing essential oils.
- scissors for cutting blotting paper.

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- Whatman paper (110 mm diameter) to absorb the various quantities of neem extract solutions to be tested.
- a 1000µl micropipette for pipetting the various solutions.

2.2. Methods

2.2.1. Weevil rearing

The weevils were reared in the entomology laboratory at 37°C. White-fleshed tuberous roots of the Djankani variety of sweet potato infected with *C. puncticollis*Boheman were taken from a farm in Bama. In the laboratory, infected samples devoid of adults were stored in plastic bins (80 cm x 30 cm x 50 cm). Each bin was closed with muslin cloth to ensure good aeration and prevent the insects from escaping. Old potatoes no longer containing larvae were removed from the bins and replaced.

2.2.1.1. Essential oil extraction

Ocimumgratissimum L and *O.basilicum* L leaves were harvested at IRSAT-Bobo and brought to the laboratory prior to essential oil extraction. The essential oils were obtained by steam distillation using a 250-litre stainless steel still. The steam entrainment principle used in this study is similar to that described by Tia et al. (2019). The essential oil yield was determined by processing 5 kg of fresh plant material, then the oil sample was stored at 4°C protected from light until their use.

The extraction yield of the essential oil was determined according to the following formula:

$$\text{Yield (\%)} = \frac{\text{mass(g)}essential\ oil}{\text{mass(g)vegetable matter}} x\ 100 \quad \text{(Equation 1)}$$

2.2.1.2. Essential oil extraction process

The essential oil was extracted from dried fresh leaves by hydrodistillation. The fresh leaves were harvested at IRSAT-Bobo. Extraction took place in the laboratory, using a device comprising gas, a decanting bulb and two tanks, one for distillation and the other for cooling. After collecting the leaves and cleaning the apparatus, the fresh leaves were placed and packed in the distillation tank. Five liters of water were added and the fire was lit after opening the gas. Sometime after cooking, the water vapor mixed with the essential oil rises through the pipes to reach the cooling tank. Here, the steam containing the oil gradually cools as it passes through the coil immersed in water. This is how the first refluxes into the decantation bulb takes place. This collects the floral water mixed with the essential oil, helping it to settle. As the ampoule filled, we opened it periodically to drain off the floral water and retain the essential oil. After a minimum of three hours, extraction was complete. With three fifty kg bags of fresh leaves, we obtained around eighty (80) ml of essential oil.

2.2.1.3. Fumigation toxicity of essential oils

Five doses of essential oils corresponding to the following respective concentrations (25; 50; 75; 100 and 125 µL/L air), calculated in relation to the volume of air in the jars (µL/L), are used in a single application. Toxicity tests are carried out by fumigation in 1 L canning jars (glass), by depositing a charge of essential oil on a 6 cm diameter filter paper disk (disk adapted to the base of the jar) to promote its evaporation into the jars. Subsequently, batches of ten unsexed adult insects of *C. puncticollis* are introduced into the jars containing a fresh, healthy tuberous root of the sweet potato. The jars are immediately sealed. Each trial is repeated four times (4 replicates). The number of dead insects in each batch (treated and untreated jars) is counted every 24 h of exposure and for 4 days (24 h, 48 h ,72 h and 96h) by observation with a hand-held magnifying glass, and the corrected percentage mortality is expressed according to Abbott's (1925) formula.

$$\text{MC (\%)} = \frac{(\text{Mt}-\text{Mo})}{(100-\text{Mo})} \quad \text{(Equation 2)}$$

With:
Mc: corrected mortality in percent

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Mt: mortality in treated batch
Mo: mortality in untreated control batch

2.2.2. Statistical analysis

The Microsoft Office 2019 Excel spreadsheet was used to enter and process the data collected and to produce the various graphs. R software version 3.6.2 was used for statistical analysis. The distribution of the data did not follow the normal distribution law. A non-parametric Kruskal-Wallis analysis was performed to detect differences between treatments. When there was a significant difference between treatments, pairwise comparison of means was performed using the pairwise t-test at the 5% threshold.

3. RESULTS AND DISCUSSION

3.1. Results

3.1.1 Average mortality rate of *Cylas puncticollis* adults to different concentrations of *Ocimungratissimum* as a function of exposure time

Figure 1 shows the results of the mean mortality rates of *C.puncticollis* adults to different concentrations of *O.gratissimun*oil as a function of exposure time of *C.puncticollis* adults. Whatever the concentration of *O.gratissimun* oil, mean mortality rates increased with the duration of exposure of *C.punticollis* adults. The analysis of variance (ANOVA) revealed a highly significant difference between mortalities, with 100% mortality of *C. puncticollis* observed from the 48th to the 96th hour of exposure with 25µL/L concentration of *O.gratissimum*. Mortality rates of *C. puncticollis* increased progressively from the 30th minute to the 24th hour. The ANOVA showed a highly significant difference between mortalities and 100% mortality of *C. puncticollis* from the 24th hour to the 96th hour of exposure with 50µL/L, 75µL/L and 100µL/Lconcentrations of *O. gratissimun*. Mortality rates of *C. puncticollis* increased progressively from the 30th minute to the 5th hour. Finally, the 125µL/L concentration of *O.gratissimum* induced significant differences between mortalities, and 100% mortality of *C. puncticollis* was observed from the 2nd hour to the 96th hour of exposure.

Table 1:Averagemortality rate of *Cylaspuncticollis*adultsexposed to different concentrations of *Ocimumgratissimum* as a function of exposure time.

	Concentrationsof*Ocimumgratissimum*				
Time	**25µL/L**	**50µL/L**	**75µL/L**	**100µL/L**	**125µL/L**
30min	18.00±6.43a	4.00±0.84a	8.00±2.02a	8.00±2.40a	70.00±10.35a
1h00mn	32.00±4.50a	6.00±1.04ab	22.00±6.93ab	22.00±6.67ab	82.00±8.36ab
1h30mn	40.00±8.02a	32.00±8.34bc	32.00±7.30ac	32.00±7.30bc	94.00±8.94b
2h00mn	44.00±8.34ab	44.00±10.34cd	52.00±10.39acd	52.00±9.44cd	100.00±0.00b
2h30mn	52.00±9.44bc	48.00±11.24cd	56.00±11.54ace	56.00±11.54de	100.00±0.00b
3h00mn	52.00±9.44bc	56.00±11.54cd	62.00±12.54bce	62.00±12.54df	100.00±0.00b
3h30	52.00±9.44c	60.00±10.70cd	66.00±13.06bce	62.00±12.54df	100.00±0.00b
4h00mn	54.00±9.54cd	68.00±11.54d	72.00±12.16ce	72.00±12.16ef	100.00±0.00b
4h30mn	66.00±10.44cd	72.00±13.54de	72.00±12.16ce	72.00±12.16ef	100.00±0.00b
5h00mn	68.00±1.194cd	72.00±13.54de	72.00±13.16ce	72.00±12.16ef	100.00±0.00b

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24h00mn	78.00±12.40de	100.00±0.00e	100.00±0.00e	100.00±0.00f	100.00±0.00b
48h00mn	100.00±0.00de	100.00±0.00e	100.00±0.00de	100.00±0.00f	100.00±0.00b
72h00mn	100.00±0.00de	100.00±0.00e	100.00±0.00de	100.00±0.00f	100.00±0.00b
96h00mn	100.00±0.00de	100.00±0.00e	100.00±0.00e	100.00±0.00f	100.00±0.00b
Probability	**$4.56.10^{-12}$**	**2.10^{-16}**	**$6.39.10^{-10}$**	**$6.39.10^{-10}$**	**$1.16.10^{-3}$**
Significance	**VHS**	**VHS**	**VHS**	**VHS**	**S**

Means followed by the same letter are not significantly different according to the pairwise-t-test at the 5% threshold; VHS: very highly significant; S: significant.

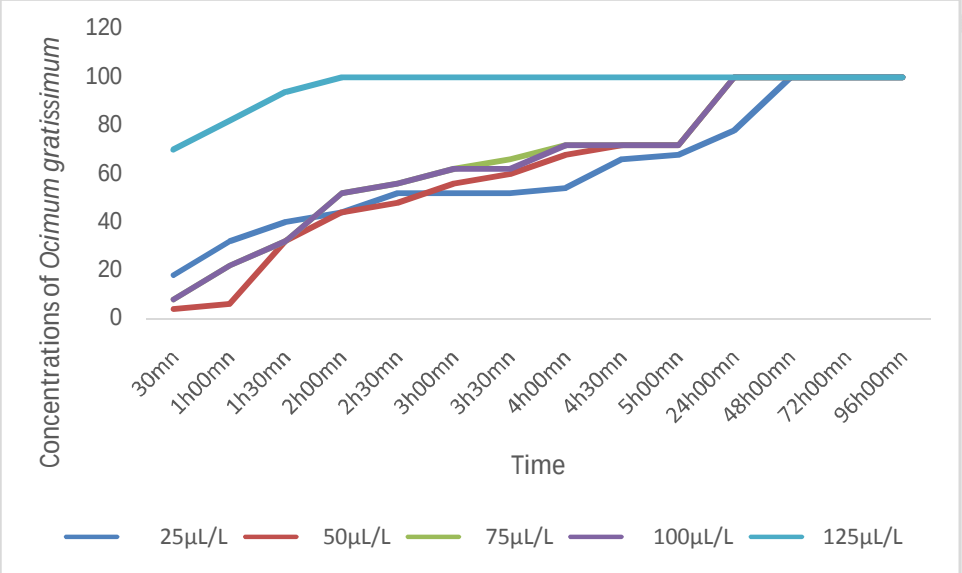

Figure 1:Averagemortality rate of *Cylaspuncticollis*adultsexposed to different concentrations of *Ocimumgratissimum* as a function of exposure time.

3.1.2 Average mortality rate of *Cylas puncticollis* adults to different concentrations of *Ocimumbasilicum* as a function of exposure time

Figure2 shows the results of mean mortality rates of *C.puncticollis* adults to different concentrations of *O. basilicum* oil as a function of exposure time. Mean mortality rates increased with the duration of exposure of *C.punticollis* adults whatever the concentration of *O. basilicum*. With 25µL/L concentration of *O.gratissimum*the ANOVA revealed a highly significant difference between observed mortalities, with 94% mortality of *C. puncticollis* observed from the 96th hour of exposure. With the 50µL/L and 75µL/L concentrations, the ANOVA showed that there was a highly significant difference between observed *C.puncticollis* adult mortalities and 98% *C.puncticollis* mortality was observed from the 96th hour of exposure. With concentrations of 100µL/L and 125µL/L, the ANOVArevealed that there was a highly significant difference between observed *C.puncticollis* adult mortalities, with 100% *C.puncticollis* mortality observed from the 24th to the 96th hour of exposure. The mortality rate of *C. puncticollis* increased progressively whatever the concentration of *O. basilicum*.

Table 2: Average mortality rate of *Cylas puncticollis* adults to different *Ocimumbasilicum* concentrations as a function of exposure time

	Concentrationsof*Ocimumbasilicum*				
Time	**25µL/L**	**50µL/L**	**75µL/L**	**100µL/L**	**125µL/L**
30min	8.00±2.36a	10.00±2.34a	0.00±0.00a	18.00±5.24a	26.00±5.84a
1h00mn	8.00±2.36a	10.00±2.34a	0.00±0.00a	32,00±6,24ab	40.00±9.47a
1h30mn	8.00±2.36a	10.00±2.34a	0.00±0.00a	40.00±5.24ab	44.00±10.77a
2h00mn	8.00±2.36a	12.00±3.44a	2.00±0.24a	44.00±6.29abc	50.00±9.49a
2h30mn	14.00±4.40a	12.00±3.44a	2.00±0.24a	52.00±8.24abc	52.00±9.86a
3h00mn	8.00±2.40a	12.00±3.44a	4.00±0.84a	52.00±8.24abc	54.00±10.90a
3h30mn	12.00±3.44a	12.00±3.44a	4.00±0.84a	54.00±9.64abc	54.00±10.90a
4h00mn	14.00±4.40a	18.00±5.24a	10.00±2.24ab	66.00±10.44bd	62.00±11.49ab
4h30mn	14.00±4.40a	22.00±4.84a	26.00±5.47bc	68.00±10.94abd	68.00±11.83ab
5h00mn	14.00±4.40a	24.00±5.25a	32.00±4.47c	78.00±9.54cd	68.00±11.83ab
24h00mn	24.00±5.25a	30.00±6.24a	36.00±5.47c	100.00±0.00d	100.00±0.00b
48h00mn	72.00±10.40b	92.00±12.03b	94.00±11.40d	100.00±0.00d	100.00±0.00b
72h00mn	83.00±12.40bc	98.0±4.47b	94.00±11.40d	100.00±0.00d	100.00±0.00b
96h00mn	94.00±5.47c	98.00±4.47b	98.00±4.47d	100.00±0.00d	100.00±0.00b
Probability	**2.10^{-16}**	**2.10^{-16}**	**2.10^{-16}**	**$4.56.10^{-12}$**	**$7.61.10^{-8}$**
Significance	**VHS**	**VHS**	**VHS**	**VHS**	**VHS**

Means followed by the same letter are not significantly different according to the pairwise-t-test at the 5% threshold; VHS: very highly significant.

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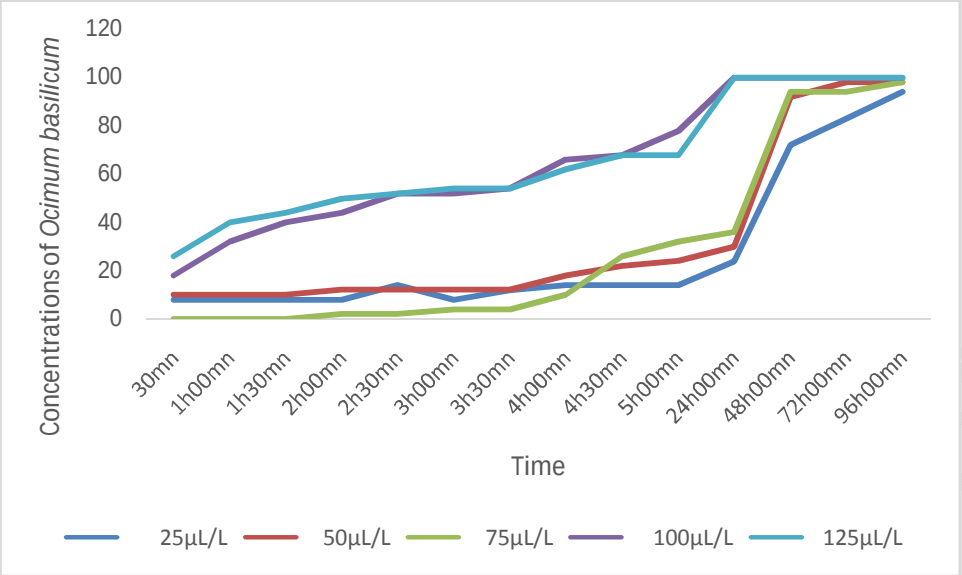

Figure 2: Average mortality rate of *Cylas puncticollis* adults to different *Ocimumbasilicum* concentrations as a function of exposure time

3.2. Discussion

The results of our studies indicate that different concentrations (25, 50, 75, 100 and 125µL/L) of *O. gratissimun* and *O. basilicum* essential oils were toxic to *C.puncticollis* adults after different exposure times.

Ocimumgratissimun essential oil was effective against *C. punticollis*. After application at different concentrations to *C. puncticollis*, high mortality rates were observed. These results could be explained by the presence of molecules such as thymol (29.5%), γ-terpinene (20, 5%) and p-cymene (12, 9%) as major constituents of the essential oil (Coulibaly et al., 2023). In Burkina Faso, *O. gratissimum* essential oilcontains γ-terpinene, which is the most abundant compound (20, 95%), followed by thymol (18, 56%) and p-cymene (11, 73%) (Ouédraogo et al., 2016). Analytical studies of *O.gratissimum* essential oilreveal the presence of hydrocarbon monoterpene (44, 9%) and oxygenate monoterpenes (41.8%) (Coulibaly et al., 2023). Plant essential oils contain monoterpenoid compounds that are toxic to insects, destroying the nervous system (Houghton et al., 2006). These compounds could be responsible for the mortality of the insect pest that is reported in this study. These results confirm the insecticidal properties of these essential oils. Indeed, the work of Konstantopoulou et al. (1992) revealed that monoterpenes in essential oils are toxic to many insects. According to Cloyd and Chiasson (2007), this oxygenated compound acts directly on the cuticle of insects and mites, causing its degradation. Thymol, one of the main compounds, interferes with synapse activity, preventing respiration by

suffocation and leading to insect death (Priestley et al., 2003; Gonzalez et al., 2013). Similar results werereportedby Tchoumbougnang et al. (2009) on *Anopheles gambiae* larvae in Cameroon and Ouédraogo et al. (2016) on the main insect pests of maize in storage in Burkina Faso.Previousstudieshadshownthat*C. citratus*and*O. canum*essential oils have significantinsecticidalactivityagainst certain insects, notably*Anophelesgambiae*Giles larvae (Tchoumbougnang et al.,2009), *Pectinophoragossypiella*Saunders adultinsects (Kobenan et al., 2018), *Aphis gossypii*aphids . (Akantetou et al., 2011).*Ocimun basilicum*oilgenerated a high mortality rate at all concentrations. From the minimum to the maximum concentration, mortality rates exceeded 90%. This could be explained by the fact that chemical compounds such as alkaloids, tannins, terpenes, steroids, flavonoids and phenols contained in the oil could disrupt the nervous system of *C. puncticollis*, preventing the transmission of nerve signals, leading to paralysis and death of the weevils. The work of Tshimenga et al. (2018) identified the presence of the same chemical compounds alkaloids, tannins, terpenes, steroids, flavonoids, phenols in *O. basilicum*extracts. Indeed, according to Pikassalé et al. (2020), *O. basilicum*oilisrich in estragol (85.5%), the active ingredient that is effective against pests. Theseresults are similar to thosereportedby Tshimenga et al. (2018) that for a dose of.2 g/mL, high mortality of the weevil *Sitophilus oryzae* insect pest of rice and maize stocks in South Kivu, Democratic Republic of Congo was observed with values of 79.4% after 24 h and 90% after 48 and 72 h. This could also explain the very high mortality rates recorded in this study with *O. basilicum* essential oil, according to Chiasson and Beloin (2007). In addition to that,disturbances in *Culex pipiens* and *Culisetalongiareolata*treatedwith*O. basilicum*werehighlightedafterexperiments carried out at our laboratory with the aim of testing essential oil effects on mosquito energy reserves (Bouzidi and Ziani, 2015). Mousavi and Valizadegan (2013) tested the biologicalactivity of *Artemisia dracunculus* essential oil, containing 71.53% estragole, by fumigation on *A. gossypii*, and found that the higher the concentration, the higher the mortality rate. This oil also acts directly on the cuticle of insects and mites. We plan to continue thisstudy in order to demonstrate the effect of these essential oils on all stages of development and specifytheir mode of action on *C. puncticollis*Boheman.

4. CONCLUSION

The use of biopesticides for the control of the weevil*Cylaspunticollis*is a promising prospect for Burkina Faso growers. The aim of thisstudywas to compare the insecticidaleffect of essential oils on *C.punticollis*Boheman, a weevil of sweetpotato (*Ipomeabatata*) in Burkina Faso. Resultsshowed the insecticidalproperties of these essential oils on adults of the sweetpotato*C.puncticollis*. The vapors of these essential oils are capable of eradicating all adults and disrupting the metabolism of *C. puncticollis*afterexposure. In general, the results achieved in this study show that the essential oil of *O.gratissimun* and *O.basilicum* were toxic to *C. puncticollis* and can significantly reduce these populations. However, it would be

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appropriate to carry out a concrete application of these oil extracts on large potato stocks in order to confirm or not their effectiveness.

DISCLAIMER (Artificial intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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