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Effects of Four Essential Oils of Aromatic Plants on Mycelial Radial Growth of *Magnaporthe oryzae* B.C.Couch., a Rice Blast Pathogen in Burkina Faso

Ouattara Souleymane[1,3,a,*], Kassankogno Abalo Itolou[2,b], Sérémé Abdoulaye[3,c], Koïta Kadidia[1,d]

[1]*Joseph KI-ZERBO University, 03 BP 7021 Ouagadougou 03, Burkina Faso*
[2]*Institute of the Environment and Agricultural Research, 01 BP 910 Bobo-Dioulasso 01, Burkina Faso*
[3]*Institute for Research in Applied Sciences and Technology, 03 BP 7047 Ouagadougou 03, Burkina Faso*
[*]*Corresponding author*

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ABSTRACT

Rice blast, aused by *Magnaporthe oryzae* B.C.Couch, is considered as the main fungal disease in rice fields in Burkina Faso. This study aimed to assess the essential oils of *Cymbopogon schoenanthus, Ocimum americanum, Ocimum gratissimum* and *Lippia multiflora* on mycelial radial growth and inhibition rate of the fungus using the contact and fumigation methods. For each essential oil, six doses were used : T0 (0 µl/ml), T1 (0.1 µl/ml), T2 (0.6 µl/ml), T3 (1.2 µl/ml), T4 (1.8 µl/ml) and T5 (2.4 µl/ml). In both tests, two treatments of synthetic fungicides namely Tma (mancozeb) and Taz (azoxystrobin) at recommended doses of 6.67 µl/ml and 3.33 µl/ml respectively. The results showed that in the contact method, essential oils of *L. multiflora, O. americanum,C. schoenanthus* and *O. gratissimum* inhibited 100% (0 cm of diameter) the fungus mycelial radial growth at doses of T3 (1.2 µl/ml), T5 (2.4 µl/ml), T2 (0.6 µl/ml) and T2 (0.6 µl/ml) respectively. As for the fumigation method, oils of *L. multiflora, O. americanum,C. schoenanthus* and *O. gratissimum* inhibited mycelial radial growth of the fungus by 100% at doses of T2 (0.6 µl/ml), T5 (2.4 µl/ml), T4 (1.8 µl/ml) and T3 (1.2 µl/ml) respectively. Mancozeb and azoxystrobin treatments inhibited radial mycelial growth by 100% and 74.1% respectively. These essential oils can be used to control rice blast in the field. The use of these essential oils in rice blast management may also help to reduce environmental pollution caused by synthetic fungicides."

[a] *soulmakos01@gmail.com* *https://orcid.org/0009-0003-6086-330X*
[b] *kassabalo@yahoo.fr* *https://orcid.org/0000-0003-3168-1972*
[c] *asereme@yahoo.fr* *https://orcid.org/0000-0003-0441-4262*
[d] *koita.kadidia@yahoo.fr* *https://orcid.org/0000-0002-1592-9635*

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Introduction

Rice blast, caused by the fungus *Magnaporthe oryzae* Cav, remains the most damaging fungal constraint to rice production, with damage that can cause yield losses of up to 100% if no protective measures are taken (Zhan et al., 2018 ; Li et al., 2019 ; Savary et al., 2019 ; Kassankogno et al., 2021). The use of chemicals such as tricyclazole, azoxystrobin and mancozeb to control *M. oryzae* has been successful in increasing yields (Moinina et al., 2018). However, their application has numerous consequences for human and animal health and the environment such as water and air pollution. It is therefore necessary to use alternative control methods such as biological control through the use of biopesticides (; Gamsore et al., 2018 ; Toundou et al., 2020). Studies have shown that essential oils possess insecticidal, bactericidal or fungicidal properties by contact or fumigation methods (Amarti et al., 2010 ; Hamdani et al., 2015). Also, according to Tiendrebeogo et al. (2017), *L. multiflora* essential oil has strong antifungal activity, totally inhibiting the mycelial growth of *B. oryzae* at 400 ppm doses. Mahomed *et al* (2022) demonstrated the fungicidal effect of essential oils of *L. multiflora*, *C. schoenanthus* and *O. americanum* in the protection of cowpea seeds. These essential oils also help to improve plant morphological parameters. According to Kobenan et al. (2019), the application of *O. gratissimum* and *C. citratus* essential oils on cotton plant improves cotton lint yield. Also, the work of Traore et al. (2023) showed that the essential oil of *L. multiflora* had a reducing effect on bacterial wilt of tomato, and the wilt index decreased as the volume of essential oil increased.

The aim is to evaluate the *effects* of four essential oils of aromatic plants on mycelial radial growth of *M. oryzae* a rice blast pathogen in Burkina Faso.

Materials and methods

Study site

The study was carried out at INERA's Farako-Bâ research station at Bobo-Dioulasso. It has a northern latitude of 11° 06' and a western longitude of 4° 20'. The soils are tropical ferruginous with a sandy-loam texture, slightly acidic and low in nitrogen and assimilable phosphorus (Nacro et al., 2011). The Figure 1 shows the location of the INERA Farako-Bâ research station.

Fungal material

The fungal material used was *M. oryzae* strain BF075 from rice leaves collected at the Farakô-Bâ site and isolated at INERA Farakô-Ba's Phytopathology laboratory. In fact, infested leaves showing symptoms were rinsed thoroughly with water and then cut into small fragments. The leaf fragments were disinfected for a few seconds in a 2% sodium hypochlorite solution, then rinsed with distilled water for 30 seconds to eliminate microflora. Fragments were then placed on blotting paper soaked in distilled water and placed in a Petri dish. Petri dishes were incubated for 3 to 4 days at 25-30°C, alternating 12 hours in the light and 12 hours in the dark, to induce sporulation and conidial formation. After incubation, Petri dishes were examined under a binocular microscope to identify conidia. Under a binocular magnifying glass, conidia were individually picked with a sterile plastic needle and cultured on PDA medium in Petri dishes to obtain a pure culture of the isolate. Among the strains obtained, strain BF075 was the most virulent, which explains why it was chosen (Kassankogno, 2016).

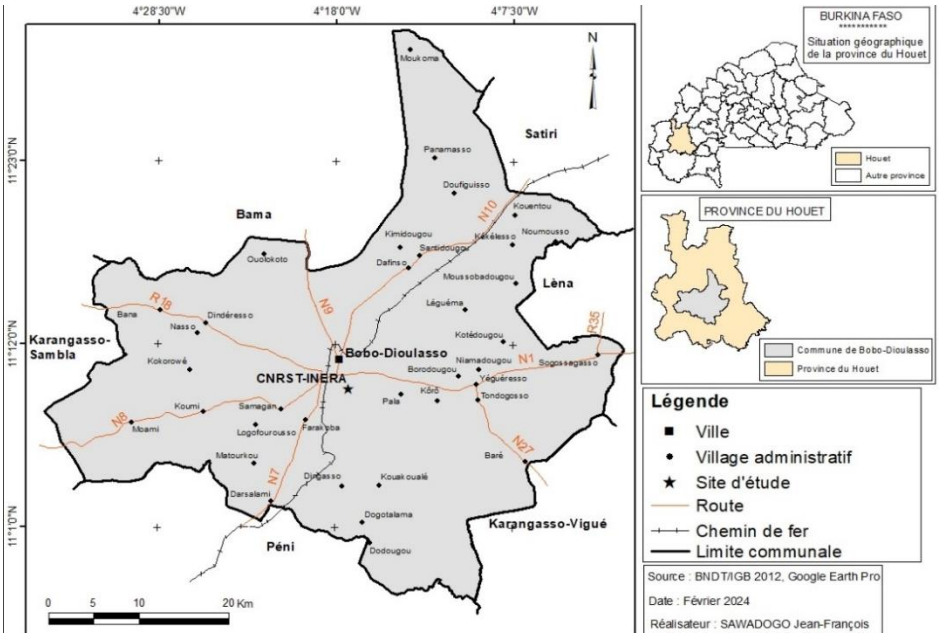

Figure 1. Location map of the Farako-Bâ research station

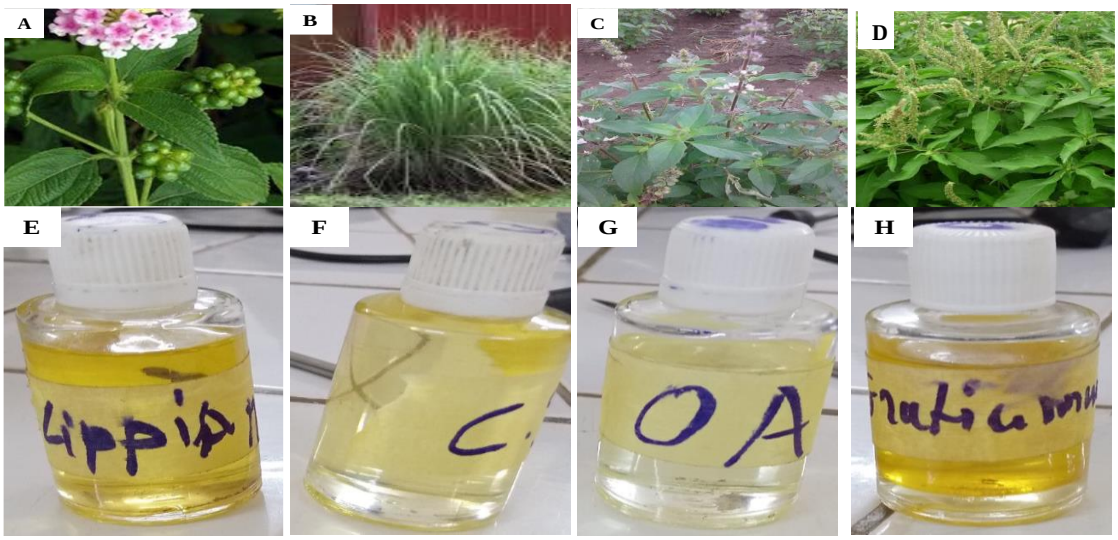

Figure 2. Aromatic plants and their essential oils.

Legend : A : Aromatic plant of *L. multiflora,* B : Aromatic plant of *C. schoenanthus,* C : Aromatic plant of *O. americanum,* D *:* Aromatic plant of *O. Gratissimum,* E : essential oil of *L. multiflora,* F : essential oil of *C. schoenanthus,* G : essential oil of *O. americanum,* H *:* essential oil of *O. Gratissimum.*

Table 1. Chemical composition of essential oils

C. schoenanthus		*L. multiflora*	
Chemical compounds	Contents (%)	Chemical compounds	Contents (%)
carène-2	16.90	2-méthyl-3-butan-2-ol	2.71
limonène	2.15	α-pinène	0.73
cis pinène hydrate	0.53	myrcène	2.21
tr pinène hydrate	0.28	α-phéllandrène	3.01
α- β-terpineol	0.56	α-terpinène	1.35
piperitone	69.01	p-cymène	26.18
α- elemène	0.82	limonène	1.07
β-caryophyllene	1.10	γ –terpinène	4.5
α- farnesene	0.09	cis isopulegone	0.82
tr. b-farnesène	0.20	tymol	29.87
ð-cadinène	0.18	acétate de thymyl	11.76
elemol	5.76	hexenylvalerate	4.51
β-eudesmol	0.79	(z) isopulogone	4.02
tiglate de citryle	0.96	β-Santalène	0.91
Total	99.33	Total	93.65
O. americanum		*O. gratissimum*	
Chemical compounds	Contents (%)	Chemical compounds	Contents (%)
a-pinène	4.7	Sabinène	6.6
sabinène	1.5	α -Pinène	1.86
b-pinène	5.7	β-Myrcène	3.97
myrcène	2.1	α-Terpinène	1.66
a-terpinène	0.2	*p*-Cymène	37.79
1.8-cinéole	60.2	d-Limonène	1.26
limonène	2.9	γ-Terpinène	3.62
cis-p-ment-2-1-ol	1.4	2-Nitro-p-Cymene	2.05
linalol	1.9	Terpinène 4-ol	1.38
terpinèn-4-ol	1.3	Copaène	1.14
a-terpinéol	6.5	β-cis-Caryophyllène	4.42
b-caryophyllène	1.9	Sélinène	1.55
trans-a-bergamotène	2.8	Thymol	24.57
d-cadinène	2.5	Camphre	5.53
Total	95.6	Total	97.4

Nebié et al. (2002); Djibo et al. (2004); Gbogbo et al. (2006); Kobenan et al. (2019).

Essential Oils and Their Extraction Protocol

The essential oils of the *L. multiflora, O. americanum,C. schoenanthus* and *O. gratissimum* aromatic plants used for the tests were extracted from the leafy twigs. The essential oils were extracted by hydrodistillation using a still at the Natural Substances Department Laboratory of the Institut de Recherche en Sciences Appliquées et Technologie. This system consists of connecting a boiler to a pot. The pot, which is connected to the cooler by a pipe (the serpentine), is responsible for containing, after weighing, fresh or dry plant organs (leaves) for a maximum operating time of three hours. Water vapour and condensed aromatic molecules were collected in a separating funnel. Supernatant oils were collected by decantation and stored in opaque bottles at 4°C, protected from light.

Chemical Composition of Essential Oils

The chemical composition and content (in %) of the essential oils of *C. schoenanthus, L. multiflora, O. americanum* and *O. gratissimum* are presented in Table 1.

Determination of The Effects of Essential Oils on Mycelial Growth of M. oryzae

The essential oils were tested using two methods:

- The contact method or "poisoned food" method (Adam et al., 1998), which involved mixing the essential oils directly into the Potato Dextrose Agar (PDA) culture medium. An emulsifier (Tween-20) was used to mix the essential oils with the PDA medium.
- The fumigation methode or micro-atmosphere method, where the essential oils were poured and then spread on the underside of the Petri dish lid (Tonzibo et al., 2013).

For each type of essential oil, six doses were prepared: T0 (0 µl/ml), T1 (0.1 µl/ml), T2 (0.6 µl/ml), T3 (1.2 µl/ml), T4 (1.8 µl/ml) and T5 (2.4 µl/ml). In both tests, two synthetic fungicides, Tma (mancozeb) and Taz (azoxystrobin), at recommended doses of 6.67 µl/ml and 3.33 µl/ml respectively were used. Petri dishes were then placed in an incubation chamber. For each method, the mycelial growth diameters (in mm) of the pathogen in each Petri dish were measured for 14 days after incubation (JAI)

at two-day intervals (Sirima et al., 2020 ; Kassankogno, 2016).

Assessment of mycelial growth: From seven days old pure culture of *M. oryzae*, one explant measuring six mm was removed and placed in the center of the Petri dish containing the culture medium. Mycelial radial growth was assessed by averaging the two perpendicular diameters passing through the middle of the explant (Sirima et al., 2020). Three replicates were performed for each concentration.

Minimum inhibition doses: The inhibition rate (IR) was calculated according to the following formula:

$$TI_{(\%)} = \left(\frac{T_0 - T}{T_0}\right) \times 100$$

With T0 = mean value recorded in the control medium,

T = mean value recorded in culture medium containing essential oil or fungicide (Sirima et al., 2020) From these inhibition rates, minimum inhibition doses were determined.

Statistical Analysis

The data collected were entered into Microsoft Excel 2013 spreadsheet software. XLSTAT.2016 software was used for analysis of variance. Means for each parameter were compared according to Fisher's test at the 5% probability threshold.

Results

Effects of Essential Oils on Mycelial Growth of M. oryzae

A variation of the radial mycelial growth of *M. oryzae* was recorded between the different oil treatments using the contact method (Figures 3, 4, 5 and 6) and the fumigation method (Figures 7, 8, 9 and 10). Analysis of variance showed a highly significant difference among the radial mycelial diameters of the different essential oils compared with the control (T0). In the contact method, the essential oils of *L. multiflora, O. americanum,C. schoenanthus* and *O. gratissimum* inhibited 100% (0 mm of diameter) the fungus mycelial radial growth at doses of T3 (1.2 µl/ml), T5 (2.4 µl/ml), T2 (0.6 µl/ml) and T2 (0.6 µl/ml) respectively. As for the fumigation method, the essential oils of *L. multiflora, O. americanum,C. schoenanthus* and *O. gratissimum* inhibited mycelial radial growth of the fungus by 100% (0 mm of diameter) at doses of T2 (0.6 µl/ml), T5 (2.4 µl/ml), T4 (1.8 µl/ml) and T3 (1.2 µl/ml) respectively. Fungicides based on mancozeb (Tma) inhibited radial mycelial growth by 100%. In both contact and fumigation methods, the synthetic fungicide mancozeb (Tma) completely inhibited the radial growth of the fungus (0 mm). In both methods, treatments T3 (1.2 µl/ml) and T4 (1.8 µl/ml) and T5 (2.4 µl/ml) of all essential oils were more effective than the synthetic fungicide azoxystrobin (Taz) during the incubation period.

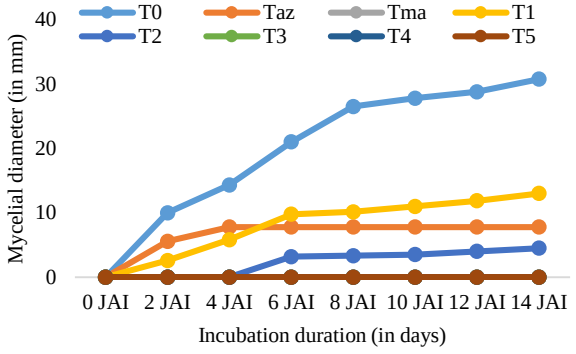

Figure 1. EO of *L. multiflora*

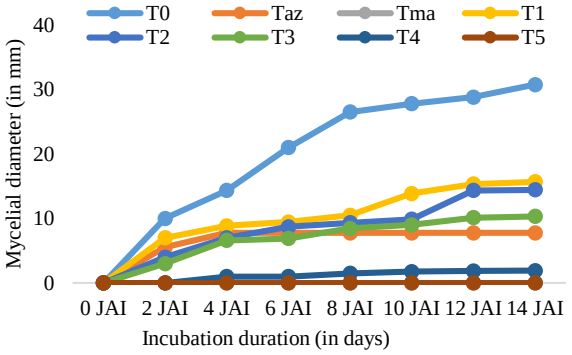

Figure 2. EO of *O. americanum*

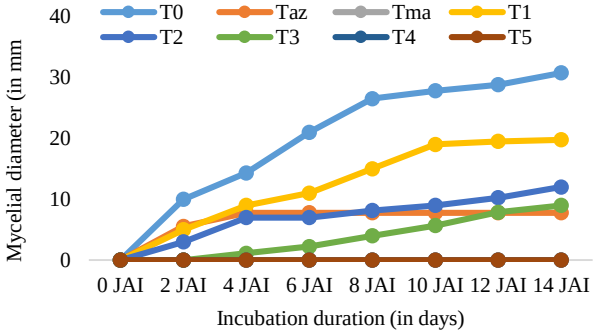

Figure 5. EO of *C. schoenanthus*

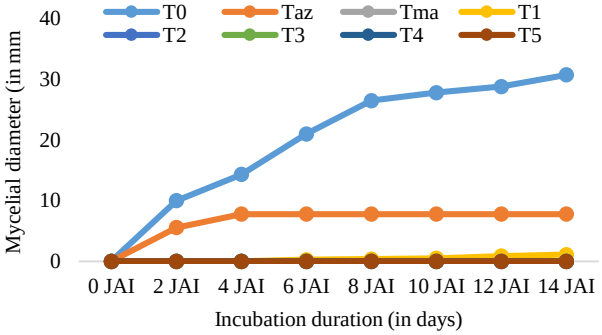

Figure 6. EO of *O. gratissimum*

Legend: JAI = Day after incubation, EO = Essential oil,.

Determination of Minimum Inhibition Doses

The minimum inhibition doses of the various essential oils on radial mycelial growth using the contact and fumigation methods are shown in Figure 11.

Analysis of variance showed a highly significant difference among the minimum inhibition doses of the different essential oils. Among the evaluated parameters, *O. americanum* essential oil recorded the highest inhibition dose T5 (2.4 µl/ml) in both the contact and fumigation methods. In the contact method, *O. gratissimum* oil recorded the lowest minimum inhibition dose T2 (0.6 µl/ml). In the fumigation method, the essential oil of *L. multiflora* recorded the lowest minimum inhibition dose of 0.6 µl/ml on mycelial growth.

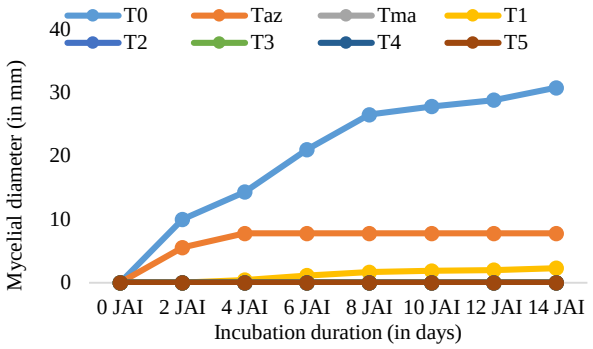

Figure 7. EO of *L. multiflora*

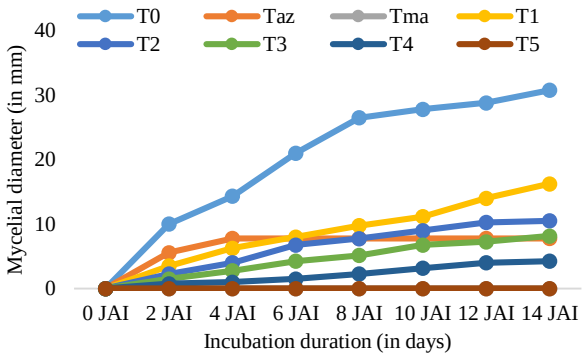

Figure 8. EO of *O. americanum*

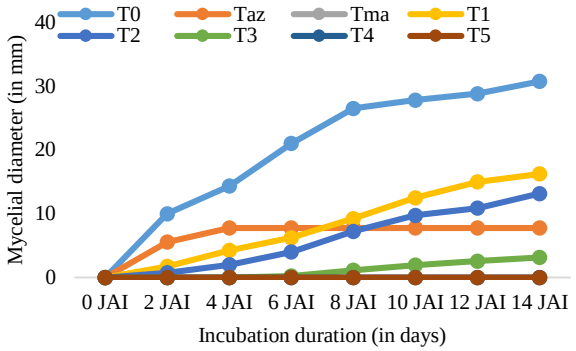

Figure 9. EO of *C. schoenanthus*

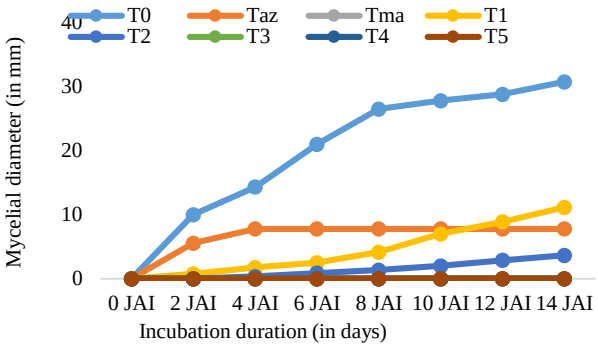

Figure 10.: EO of *O. gratissimum*

Legend: JAI = Day after incubation, EO = Essential oil.

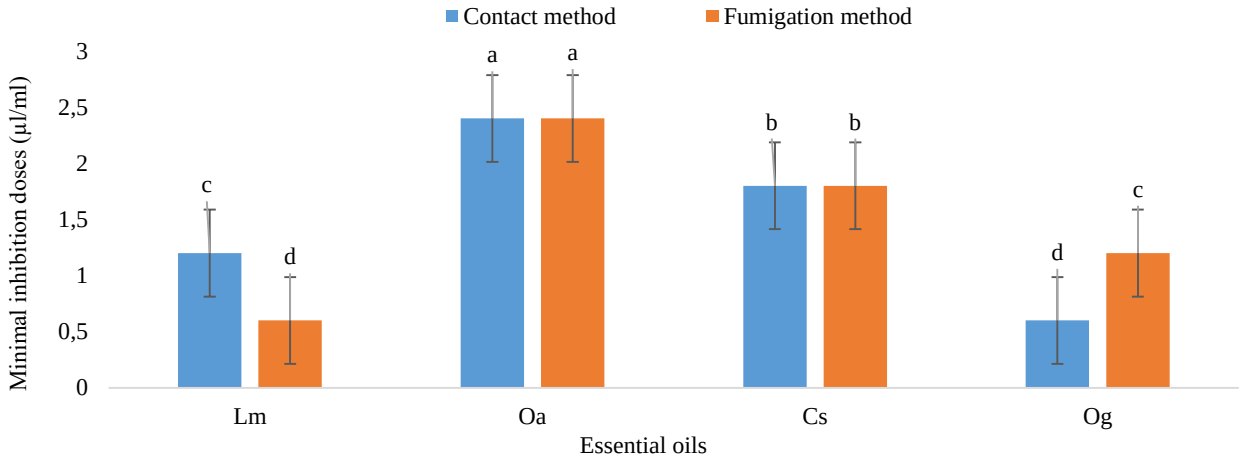

Figure 11. Minimal inhibition doses of essential oils on radial mycelial growth of *M. oryzae.*
Legend : *Oa = O. americanum, Lm = L. multiflora, Cs = C. shoenanthus, Og = O. gratissimum.*

Discussion

The effect of essential oils on the growth of *M. oryzae* in vitro varied according to the type of oil and the method used. *O. gratissimum* essential oil was the most effective in inhibiting radial mycelial growth of the fungus. This effectiveness in reducing radial mycelial growth can be explained by its content of major elements, its antifungal properties and its chemical composition, which enable it to stop or slow down the fungus' development (Mohamed et al., 2012). These results can also be explained by a probable deactivation or disruption of the fungus's operating system by essential oils. Indeed, Ambindei et al. (2014) reported that antifungal molecules can deactivate fungal function by disrupting the structure and function of fungal cell membranes or organelles, and inhibiting nuclear material or protein synthesis.

The inhibitory effect of these oils can be attributed to their major compounds (Ambindei et al., 2014). According to Sirima et al. (2020), the essential oil of *C. schoenanthus* and *L. multiflora* exhibited strong antifungal activity, stopping the mycelial growth of *Alternaria sp* isolates at doses ranging from 5% to 100%. For Tiendrebeogo et al. (2017), the essential oil of *L. multiflora* exhibits strong antifungal activity, totally inhibiting the mycelial growth of *M. oryzae* at 600 ppm. They also showed that this essential oil totally reduced the mycelial growth of F. moniliforme and *B. oryzae* at 100 ppm and 400 ppm respectively. These results can be explained by a probable deactivation or disruption of the fungus's operating system by essential oils. The work of Hamdani *et al* (2015) showed strong 100% inhibition of Fusarium spore germination by *C. aurantium sp* and *F. oxysporum* by *C. sinensis*, while

essential oils of *C. limon* and *C. reticulata* stimulated spore germination by 48% and 53% respectively in Alternaria sp. The Work carried by Adjou and Aoumanou (2013) demonstrated the antifungal activity of *O. americanum* essential oils on several toxigenic strains of the Aspergillus and Fusarium genus. Another species of the same genus, namely *O. basilicum*, inhibited fungi influencing germination of maize and cowpea at different concentrations (Gbogbo et al., 2006). Zidda *et al* (2008) also demonstrated the efficacy of *C. schoenanthus* essential oils against fungi transmitted by sorghum and millet seeds. The inhibitory effect of these oils could be attributed to the major compounds in the chemical molecules, such as piperitone in *L. multifmora* oil.

Conclusion

The various tests carried out in this study on essential oils enabled us to verify their efficacy against *M. oryzae*. All essential oils were effective in inhibiting *M. oryzae*. However, the essential oils of *O. gratissimum* and *L. multiflora* showed better minimum inhibitory doses on mycelial radial growth of *M. oryzae*, with values of 0.6 µl/ml in contact method and 0.6 µl/ml in fumigation méthod respectively. These results attest to the potential of essential oils as a natural means of controlling the pathogen responsible for rice blast. These essential oils can be tested in the field to assess their effectiveness in controlling rice blast. They should be also tried against other fungi that are mainly seed-borne in order to eradicate the seed-borne pathogen.

Declarations

Acknowledgments

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Author Contributions

OS planned the experiments, interpreted the results, analysed the data statistically, and KK supervised the project.

Conflict of interest

The authors declare no conflicts of interest.

References

Adam, K., Sivropoulou, A., Kokkini, S., Lanaras, T., & Arsenakis, M. (1998). Antifungal Activities of *Origanum vulgare* subsp. *Hirtum*, *Mentha spicata*, *Lavandula angustifolia* , and *Salvia fruticosa* Essential Oils against Human Pathogenic Fungi. *Journal of Agricultural and Food Chemistry*, *46*(5), 1739-1745. https://doi.org/10.1021/jf9708296

Adjou, E., & Aoumanou, M. (2013). Efficacité des extraits de plantes dans la lutte contre les moisissures toxinogènes isolées de l'arachide en post-récolte au Bénin. *Journal of Applied Biosciences*, *70*(1), 5555. https://doi.org/10.4314/jab.v70i1.98755

Amarti, F., Satrani, B., Ghanmi, M., Farah, A., Aafi, A., Aarab, L., Ajjouri, M. E., & Chaouch, A. (2010). Chemical composition and antimicrobial activity of essential oils of *Thymus algeriensis* Boiss. & Reut. Et *Thymus ciliatus* (Desf.) Benth. Du Maroc. *Biotechnol. Agron. Soc. Environ.*, *14*(3), 41_48.

Ambindei, W. A., Ngouné, L. T., Sameza, M. L., Sonwa, E. T., Nguimatsia, F., & Dongmo, P. M. J. (2014). Antifungal Activities against some Aspergillus species of the Essential oils of *Canarium schweinfurthii* and *Aucoumea klaineana* growing in Cameroon. *3*(5), 691-701.

Djibo A K., Samaté A D., Nacro M. 2004. Composition chimique de l'huile essentielle de *Ocimum americanum* Linn., syn. O. canum Sims du Burkina Faso. C. R. Chimie 7, 1033-1037

Gamsore, I., Ouattara, L., Ouoba, P., Bonzi, S., & Somda, I. (2018). Antifungal Activity and Phytotoxicity of *Vitex simplicifolia* Oliv. Leaves Essential Oil. *Journal of Agricultural Science*, *10*(11), 203. https://doi.org/10.5539/jas.v10n11p203

Gbogbo, K. A., Batawila, K., Anani, K., Prince-David, M., Gbéassor, M., Bouchet, P., & Akpagana, K. (2006). Activité antifongique des huiles essentielles de *Ocimum basilicum* L. (Lamiaceae) et *Cymbopogon schoenanthus* (L.) Spreng. (Poaceae) sur des micromycètes influençant la germination du Maïs et du Niébé. *Acta Botanica Gallica*, *153*(1), 115-124. https://doi.org/10.1080/12538078.2006.10515526

Hamdani, F. Z., Allem, R., Meziane, M., Setti, B., Ali, A. S., & Bourai, M. (2015). Chemical composition and antifungal activity of essential oils of Algerian citrus. *African Journal of Biotechnology*, *14*(12), 1048-1055. https://doi.org/10.5897/AJB2013.12140

Joseph, M., Gladrich, M. T. F., Emmanuelle, L. M. J., Makanga, O. L. D. É., & Attibayeba, A. (2022). Effets Insecticide et Insectifuge des Huiles Essentielles de Cinq Plantes Aromatiques sur la Bruche de Haricot Cultivé en République du Congo. *European Scientific Journal ESJ*, *19*(6), 294-329. https://doi.org/10.19044/esipreprint.12.2022.p361

Kassankogno, A. I., Sidibe, G., Guigma, A. K., Nikiema, C. B., & Nana, A. (2021). Characterization of leaf symptoms and evaluation of the pathogenicity of a few isolates of *Curvularia lunata* on three rice varieties (*Oryza sativa* L) produced in Burkina Faso. *Afrique SCIENCE*, *19*(4), 106-117.

Kassankogno. (2016). Genetic and pathological diversity of *Magnaporthe oryzae* (Couch), agent of rice blast in Burkina Faso and Togo, and sustainable disease management methods. PhD thesis, 198.

Kobenan, K. C., Kouakou, B. J., Bini, K. K. N., & Kouakou, M. (2019). Effets des Huiles Essentielles de *Ocimum gratissimum* L. et de *Cymbopogon citratus* Stapf sur les Paramètres de Croissance et de Production du Cotonnier en Côte d'Ivoire. *European Journal of Scientific Research*, *154*(1), 21-35.

Li, W., Chern, M., Yin, J., Wang, J., & Chen, X. (2019). Recent advances in broad-spectrum resistance to the rice blast disease. *Current Opinion in Plant Biology*, *50*, 114-120. https://doi.org/10.1016/j.pbi.2019.03.015

Mahomed, T., Elisabeth, Z. P., Ignace, S., Romain, S. W., & Roger, N. H. C. (2022). Efficacité fongicide de trois biopesticides à base d'huiles essentielles sur les principaux champignons associés aux semences de niébé au Burkina Faso. *J. Soc. Ouest-Afr. Chim.*, *051*, 38-44.

Mohamed, D., Kouabenan, A., Nicaise, L. A., Brahima, C., Daouda, A., & Daouda, K. (2012). *In vitro* comparative activities ofof two synthetic fungicides and two essential oils, on telluric fungi of vegetable crops in Côte d'Ivoire. *Journal of Applied Biosciences*. 50, 3520-3532.

Mohamed, D., Kouabenan, A., Nicaise, L. A., Brahima, C., Daouda, A., & Daouda, K. (2012). Activités comparées i*n vitro* de deux fongicides de synthèse et de deux huiles essentielles, sur des champignons telluriques des cultures maraîchères en Côte d'Ivoire. *Journal of Applied Biosciences*. 50, 3520-3532.

Moinina, A., Boulif, M., & Lahlali, R. (2018). Rice (*Oryza sativa*) cultivation and its main phytosani- tary problems. *Rev. Mar. Sci. Agron. Vét*. 6(4), 544-557.

Nacro, S., Ouedraogo, S., Traore, K., Sankara, E., Kabore, C., & Ouattara, B. (2011). Effets comparés des pratiques paysannes et des bonnes pratiques agricoles de gestion de la fertilité des sols sur les propriétés des sols et les rendements des cultures dans la zone sud soudanienne du Burkina Faso. *International Journal of Biological and Chemical Sciences*, *4*(4). https://doi.org/10.4314/ijbcs.v4i4.63042

Nébié R H C,. Sérémé A., Bélanger A., Yaméogo R. et Sié P S. 2002. Etude des plantes aromatiques au Burkina Faso. Caractéristques chimiques et biologiques de l'huile essentielle de *Lippia multiflora* Moldene. J. Soc. Ouest-Afric. Chim : 013. 27-37.

Savary, S., Willocquet, L., Pethybridge, S. J., Esker, P., McRoberts, N., & Nelson, A. (2019). The global burden of pathogens and pests on major food crops. *Nature Ecology & Evolution*, *3*(3), 430-439. https://doi.org/10.1038/s41559-018-0793-y

Sirima, A., Sereme, A., Sereme, D., Koïta, K., Nana, T. A., & Sawadogo, M. (2020). Effects of four essential oils on radial mycelial growth of an isolate of *Alternaria* sp. in Burkina Faso. *International Journal of Biological and Chemical Sciences*, 14(3). https://doi.org/10.4314/ijbcs.v14i3.10

Tiendrebeogo, A., Ouedraogo, I., Bonzi, S., & Kassankogno, A. I. (2017). Study of the antifungal activity of extracts of *Cymbopogon citratus* (DC.) Stap, *Eclipta alba* L., *Lippia multiflora* M. and *Agave sisalana* P. *International Journal of Biological and Chemical Sciences*, 11(3), 1202. https://doi.org/10.4314/ijbcs.v11i3.22

Tonzibo, Z. F., Koffi, A. M., Wognin, E. L., Bedi, G., & Chalchat, J. C. (2013). Intraspecific Chemical Variability of Essential Oil of *Hoslundia opposita*. *American Journal of Analytical Chemistry*, *04*(02), 77-82. https://doi.org/10.4236/ajac.2013.42010

Toundou, O., Palanga, K. K., Simalou, O., Abalo, M., Woglo, I., & Tozo, K. (2020). Biopesticide Plants species of the mining area of Tokpli (South-Togo) effects on Okra (*Abelmoschus esculentus*) protection against *Aphtona spp. International Journal of Biological and Chemical Sciences*, *14*(1), 225-238. https://doi.org/10.4314/ijbcs.v14i1.19

Traore, O., Boro, F., Nikiéma, E. W., & Wonni, I. (2023). Efficacité du compost enrichi à l'huile essentielle de *ocimum gratissimum* L. sur le flétrissement bactérien de la tomate cause par *Ralstonia solanacearum* E.F. smith dans la région des Hauts-Bassins au Burkina Faso. *Agronomie Africaine*, *35*(2), 285-295 (2023).

Yarou, B. B., Silvie, P., Komlan, F. A., Mensah, A., Alabi, T., Verheggen, F., & Francis, F. (2017). Pesticidal plants and the protection of vegetable crops in West Africa (bibliographic synthesis). *Biotechnol. Agron. Soc. Environ*, 21(4), 288-304.

Zhan, L., Ding, Z., Peng, D., Peng, H., Kong, L., Liu, S., Liu, Y., Li, Z., & Huag, W. (2018). Evaluation of Chinese rice varieties resistant to the root-knot nematode *Meloidogyne graminicola*. Journal of Integrative Agriculture, 17(3), 621-630. https://doi.org/10.1016/S2095-3119(17)61802-1.

Zidda, D. P., Ouali, P. E., Soalla, W. R., & Guissou, K. M. L. (2008). Importance of seed-borne fungi on sorghum and pearl millet in Burkina Faso and their control using plant extracts. *Pakistan Journal of Biological Sciences.* 11, 321-331. https://doi.org/10.4236/ajps.2023.148059