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BIOLOGICAL CONTROL POTENTIAL OF ESSENTIAL OILS OF DIFFERENT PLANT SPECIES ON *COLLETOTRICHUM GLOEOSPORIOIDES* (PENZ.) PENZ. & SACC., THE PATHOGENIC AGENT OF MANGO ANTHRACNOSE

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ABSTRACT: Mango plays an economically strategic role in the horticultural sector of many countries around the world, particularly in Africa. In Senegal, it represents 60% of fruit production and largely dominates the export market. However, mango production is facing many phytosanitary constraints of phytopathological or entomological origin the main of which is anthracnose caused by *Colletotrichum gloeosporioides.* For the controlof this fungal pathogen, synthetic fungicides are often used with the known negative impact on human, animal and environment. The essential oils of various aromatic plants are reported to have great potential on fungal pathogens. Some of them, extracted from *Eugenia caryophyllata*, *Mentha piperita*, *Cymbopogon citratus* and *Eucalyptus camaldulensis* have been used to test their *in vivo* and *in vitro* antifungal activity on *C. gloeosporoides* in order to improve mango fruit quality, shelf life and market value. The *in vivo* efficacy of these essential oils was tested on Keitt variety already showing symptoms of anthracnose in field and then on local variety "bouko diekhal" inoculated with strains of *C. gloeosporioides*. The treatment consists by soaking mangoes in different concentrations of essential oils and determining incidence and severity. The essential oil of *E. caryophyllata* (clove) showed the best efficacy with total inhibition of mycelial growth of *C. gloeosporioides* at the concentration of 800ppm. Mangoes inoculated with the fungus showed a severity rate of 10.22% ± 8.37% with the concentrationof 500ppm while for the control mangoes, treated with distilled water displayed 39.44 ± 12, 36% severity. Treatment of the fruits with the essential oils of *Mentha piperita* (peppermint) and *Cymbopogon citratus* (lemongrass), at the respective concentrations of 3000ppm and 2300ppm, led also to a complete inhibition of mycelial growth of the fungus. These results are promising with respect to the potential use of essential oils for the biological control of pathogenic fungi causing diseases of mango fruit.

KEYWORDS: *Colletotrichum gloeosporioides*, essential oils, biological control, Senegal

I. INTRODUCTION

Mango is the sixth most produced fruit in the world with more than 50 million tons produced in 2017 on more than 50 million hectares (FAOSTAT., 2019). In Senegal, its production is exposed to many phytosanitary constraints due to pests and diseaeses (Diedhiou et al., 2007; Ndiaye et al., 2008). Anthracnose, caused by Colletotrichum gloeosporioides (Penz.) Penz. & Sacc (Arauz, 2000, Zakaria et al., 2015), remains the most important fungal disease of mango in pre and post harvest stage with greater losses in the post harvest stage (Nelson, 2008, Pardo De la Hoz et al. ., 2016). In Senegal, anthracnose can cause losses ranging from 42 to 90% depending on climatic conditions (Mbaye, 2006; Diédhiou et al., 2014). Because of the environmental and health problems caused by synthetic fungicides, the search for alternatives becomes necessary and essential oils representa promising way for the biological control of this fungal disease (Cissé et al., 2020). The effectiveness of certain essential oils on many phytopathogenic agents has already been reported (Glitho et al. (2004), Pandey et al (2012), Ba (2014), Vidal et al. (2018), Cissé et al. (2020)).This study was therefore carried out with the aim of testing the antifungal efficacy of the essential oils of Eugenia caryophyllata, Mentha piperita, Cymbopogon citratus and Eucalyptus camaldulensis on mango anthracnose caused by C.gloeosporioides.

II. MATERIAL AND METHODS

Fungal material : Strains of Colletotrichum gloeosporioides were isolated from infested mangoes of Keitt variety from Casamance.

Essential oils : The essential oils of cloves (Eugenia caryophyllata), and the fresh leaves of Eucalyptus camaldulensis were extracted by steam distillation. Mentha piperita and Cymbopogon citratus essential oils were

obtained from France. The ready for use essential oils after extraction or upon arrival were stored in tinted bottles to avoid denaturationby light.

In vitro activity of essential oils on mycelial growth of Colletotrichum gloeosporioides : Preparation of fungal cultures :The essential oils were incorporated into the PDA (Potato Dextrose Agar) culturemedium after autoclaving at a temperature of 121 °C, and 1 bar pressure for 25 minutes. After cooling down to ≈50 °C the sterilized culture media was poured into Petri dishes of 9 cm in diameter at a rate of 20 ml each. For the tested concentration of essential oils, 3 PDA plates representing 3 replicates were inoculated with 3 mm diameterof agar disc colonized by a pure culture of Colletotrichum gloeosporioides aged of 7 days. An incubation period of 8 days, corresponded to time interval taken by the fungus to fill the non-treated Petri dishes, was considered.

Evaluation of mycelial growth : Mycelial growth was assessed every 48h by calculating the average colony diameter of perpendicular measurements passing through the middle of the fungal colony. Three repetitions are performed for each concentration. Growth inhibition rates (GIR) were determined according to the formula from Doumbouya et al. (2012):
GIR (%) = (T-E) * 100 / T; where
GIR = Growth inhibition rate
T = Average diameter of fungal colony in the control treatment (in cm)E = Average diameter of fungal colony in treated plates (in cm)

In vivo activity of essential oils on Colletotrichum gloeosporioides
Preparation of spore's suspension and inoculation : Pure culture of a 10 days old strain of Colletotrichum gloeosporioides was used. 10ml of sterile distilled water is poured in the petri dsih containing the pure culture. The mycelium was then scraped with a scalpel blade and filtered in order to have a spore suspension free from any mycelial fragments. Inoculation of the pathogen was done by creating two wounds with a depth of 1.5mm, one at the level of the peduncle and another at the apex of the mango fruit. Subsequently, 50 µl of the C. gloeosporioides spore suspension is inoculated by using a micropipette. After inoculation, mangoes are kept at room temperature (about 25°C) for 5 minutes for drying before the tests by soaking.

Post-harvest treatment of mangoes infected in field (Keitt variety) : Six treatments were carried out and for each treatment 12 mangoes were soaked in the solution for 3 minutes then air dried. The different treatments considered were hot water at 51°C during 5 minutes, Prochloraz (reference control), Eugenia caryophyllata, Mentha piperita, Cymbopogon citratus, and Eucalyptus camaldulensis.

Post-harvest treatment of mangoes artificially inoculated by C.gloeosporioides : After inoculation with spore suspension of Collettotrichum gloeosporioides and drying at room temperature (25°C) during 10mn, the mangoesare soaked one by one with nine mangoes per treatment for 2 minutes in different concentrations of essential oilsadded with 5 ml of Tween 80 (0.1%). After soaking, the mangoes are left at room temperature.

Table 1: Different concentrations used for treatments

Treatment	oncentration (ppm) with Keitt	Concentration (ppm) with bouko diékhal
E.caryophylatta	5000	500
E.camaldulensis	5000	5000
C.citratus	Not used	2000
M.piperita	5000	3000
Prochloraz	5000	Not used
Hot water 51°C (5mn)	0	Not used

Evaluation of incidence and severity of anthracnose : After treatment, the incidence and severity of anthracnose were assessed. The evaluation was carried out every 48 hours for the Keitt variety and every week for the local variety "bouko diekhal" during 15 days.
The incidence (I) was determined according to the following formula:

$$I = \frac{n}{N} * 100$$

Where n = number of mango showing symptoms and N = total number of mangoes
Disease severity was assessed using the following scale: 0 to 4 is used with (0) = no symptoms; (1) = 1 to 25%of mango surface showing symptoms; (2) = 26 to 50% of mango surface showing symptoms; (3) = 51 to 75% surface showing symptoms; (4) = 76 to 100% of mango surface showing symptoms
The severity of the disease in each replication of a treatment was determined according to the following formula:

$$S = \frac{\sum(ni \times si)}{N \times Z} * 100$$

Where ni = number of mango of severity i; si = partial severity i; N = total number of mango; Z = the greatest severity index (4)

Statistical analyses : The data was processed with R.3.2.3 software (R Core Team, 2015). A two-factor analysisof variance (ANOVA) was performed using the aov function of the agricolae package (de Mendiburu, 2015).

III. RESULTS

Activity of essential oils on mycelial growth of Colletotrichum gloeosporioides : The different essential oils used demonstrated good antifungal activities. An inhibition of mycelial growth of C. gloeosporioides was noted at various concentrations (Figure 1). With the extract of E. caryophyllata, the growth inhibition of the mycelium of the fungus varied from 52% at 500 ppm to 100% at 800ppm, showing thereby a strong effectiveness. The sametrend was observed with lemongrass and mint extracts, only the effective concentration were higher, 2300ppm and 3000ppm respectively. E. camaldulensis essential oil was less effective with the highest inhibition rate of 58.03 obtained at 10.000ppm.

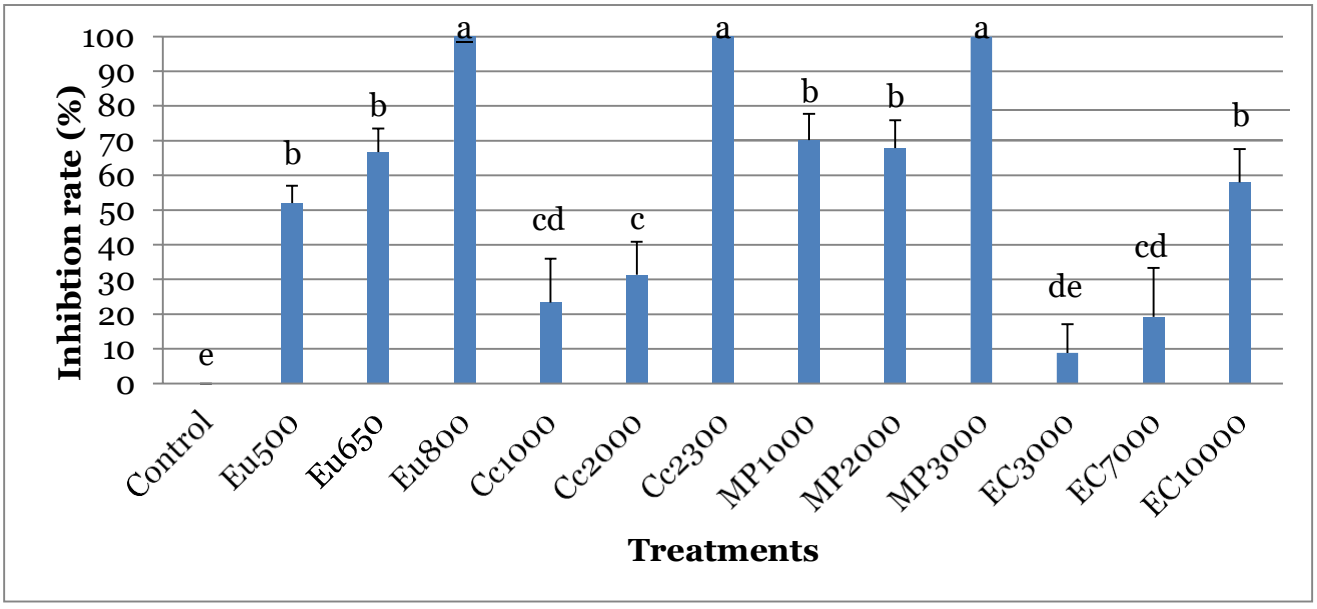

Figure 1: Activity of essential oils on the mycelial growth of Colletotrichum gloeosporioides (n=39, p=9, 61e-16), Control = Distilled water + Tween 80 (0.1%), Eu = Eugenia caryophyllata, Cc= Cymbopogon citratus, MP=Mentha piperita and EC=Eucalyptus camaldulensis

Activity of essential oils on naturally field infested mangoes : With the essential oils of Eugenia caryophyllata, Mentha piperita and Eucalyptus camaldulensis disease incidence and severity were reduced down as compared tothe absolute control and the reference control (Figure 2). The disease incidence reached a maximum value of 41.66% with the treatments with hot water (51°C during five minutes) and essential oil of E. camaldulensis. Themangoes treated with essential oils of E. caryophyllata, M. piperita, and the reference control have respective incidence of 25%, 33.33% and 25%. The average severities obtained with the absolute control, hot water and the reference control are respectively 19.16 ± 26.44%, 15.83 ± 22.34% and 8.33 ± 12.63%. Essential oil of E. caryophyllata shows the greatest efficiency with an average severity of 7.5 ± 14.22% followed by the essential oilof M. piperita with 8.95 ± 17.69% and last comes the essential oil of Eucalyptus camaldulensis with 13.41 ± 21.82%. Moreover, Eugenia caryophyllata has a most effective antifungal activity than the synthetic fungicide, Prochloraz.

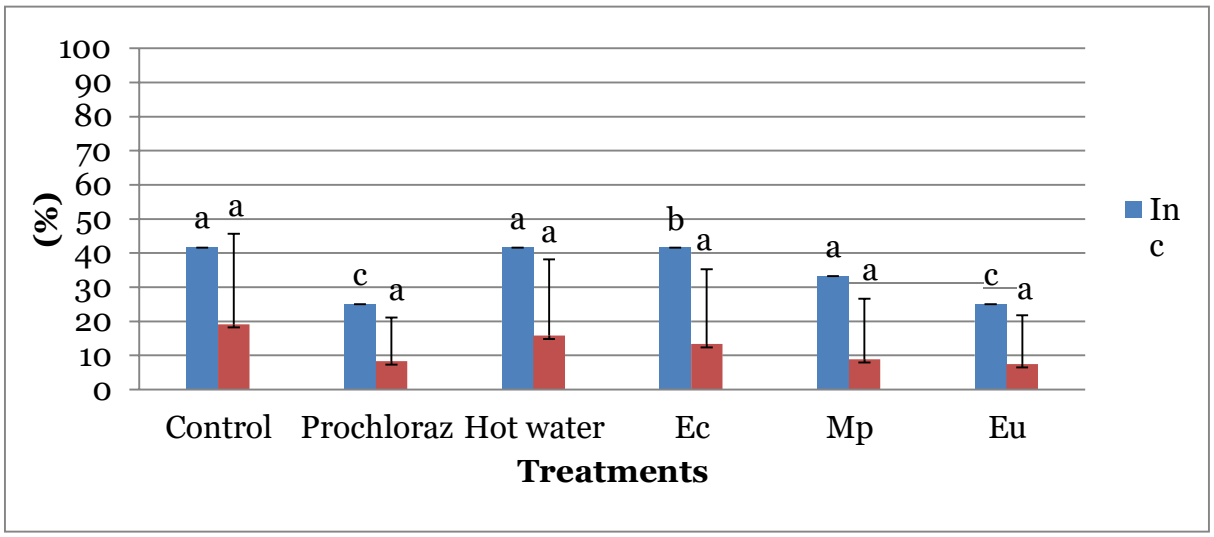

Figure 2 : Incidence and severity of mango anthracnose for infested fruits on field (n=72, PInc= 2e-16, PSev=0.673), Inc = incidence, Sev = Severity, Control = Distilled water + Tween 80 (0.1%), Prochloraz= Synthetic fungicide as reference control, Ec = Eucalyptus camaldulensis, Mp= Mentha piperita, Eu= Eugeniacaryophyllata.

Activity of essential oils on inoculated mangoes : The essential oils used show good efficacy on inoculated mango by C. gloeosporioides. A relatively high incidence of anthracnose was noted with all the treatments (figure3). With E. camaldulensis and C. citratus, an incidence of 100% is obtained at the respective concentration of 5000 and 3000ppm. Essential oils of M. piperita and E. caryophyllata have respectively incidence of 88.88% and55.55%. For the severity, 39.44 ± 12.36% is noted for the control. The essential oil of E. caryophyllata demonstrated the greatest efficiency followed by M. piperita and C. citratus with respective severities of 10.22 ±8.37%, 12.66 ± 7.95% and 15.55 ± 9.16%. E. camaldulensis is the least effective where the severity of symptomsreaches 21.11 ± 6.50%. The analysis of variance performed on the incidence and severity of the disease shows that the effect of treatment is statistically significant (P value <0.05).

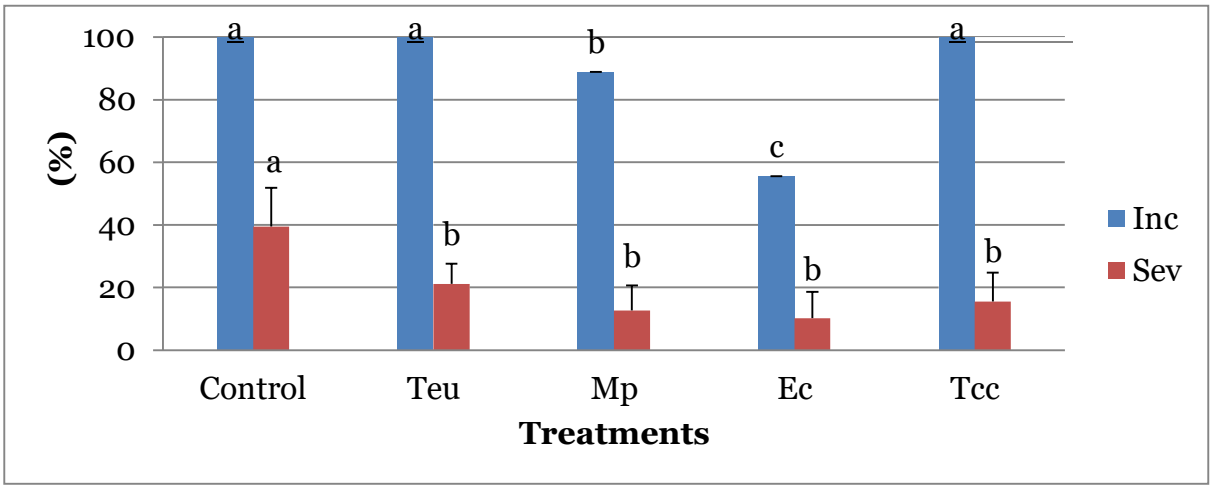

Figure 3 : Incidence and severity of mango anthracnose on inoculated fruits (n=45, Pinc=2e-16, Psev=1.49e-07),Inc = Incidence, Sev = Severity, Control = Distilled water + Tween 80 (0.1%), Teu = Eucalyptus camaldulensis , Ec = Eugenia caryphyllata, Mp = Mentha piperita, , Tcc = Cymbopogon citratus.

IV. DISCUSSION

The test of essential oils on Colletotrichum gloeosporioides responsible for mango anthracnose showed good efficacy with a variability related to the essential oil and the concentration. The essential oil of E. caryophyllata demonstrated the greatest efficiency with a complete inhibition of the in vitro mycelial growth of Colletotrichum gloeosporioides at 800ppm. Kocić-Tanackov and Dimić (2013) obtained with this same oil a total inhibition of Aspergillus flavus at 500ppm. The essential oil extracted from clove is mainly composed of eugenol (81.13-84.44%) (Sohilait., 2015). The in vitro toxicity of eugenol to fungi has already beenreported by Hamini-Kadar et al. (2014) on phytopathogenic fungi of the genus Penicillium, Fusarium, Aspergillusand Alternaria. Average severities of 5% at 5000ppm and 10.22% at 500ppm, respectively, were obtained on mangoes naturally field infested and those inoculated with Colletotrichum gloeosporioides. He et al. (2007) haveshown good in vitro and in vivo efficacy of eugenol against Candida albicans. With lemongrass, a total inhibitionof mycelial growth is obtained at 2300ppm. Traoré (2018) noted a total reduction of mycelia of Fusarium oxysporum at 1200ppm while Stangarlin et al. (2011) reported that the use of 1, 20, 40, and 60µL of this essentialoil has an inhibitory effect on the mycelial growth of Colletotrichum martinii, responsible agent of pepper anthracnose.

The inoculated mangoes exhibited an average severity of 15.55 ± 9.16% when treated with C. citratus essential oil compared to control mangoes that displayed a severity of 39.44 ± 12.36%. According to Traoré (2018), the essential oil of C. citratus exerts only partial control of post-harvest fungal diseases in mango. For Mentha piperita essential oil, complete inhibition of mycelial growth of Colletotrichum gloeosporioides was obtained at 3000ppm. These results are similar to those of Cissé et al. (2020). In the same way, Padman et al. (2012) obtained an inhibition of the mycelial growth of C. gloeosporioides responsible of leaf spot diseases of Murraya koenigii at 2500ppm. The chemical composition of essential oil of Mentha piperita is essentially menthol (28 to 42%) in association with menthone, limoneme, β-terpinene and peritone oxide (Bouhdid et al., 2012; Yadegarinia et al., 2006). These compounds considerably reduce the mycelial diameter of fungi leading to an alteration in their metabolism until their total destruction (Zani et al. (1991)). Mangoes infested in the field and treated with the essential oil of M. piperita presented an average severity of 8.95 ± 17.69% compared to the control (19.16 ± 26.44%). Sellamuthu et al. (2013) obtained a reduction in lesion size in avocado and Thymus vulgaris respectively at the concentration of 1060ppm and 667ppm after their inoculation with C. gloeosporioides.

Similar observations were made by Cissé (2016), who obtained a reduction of lesion diameters from 7.47 ± 2.91cm down to 3.04 ± 2.43cm respectively for control and treated mangoes with this same essential oil at a concentration of 3000ppm. In the present work, the essential oil of Eucalyptus camaldulensis was the least effective both in vitroand in vivo. When it was applied at 10000 ppm, the observed reduction of mycelial growth was only 58.03 ± 9.50%. With this same concentration, Cissé et al. (2020) and Gakuubi et al. (2017) respectively obtained 84.07% inhibition of mycelial growth of C. gloeosporioides and 100% inhibition of mycelial growth of Fusarium sporotrichioides and Fusarium graminearum. It is known that, the essential oil of E. camaldulensis is mainly composed of eucalyptol, 1,8-cineole, α-pinene and γ-terpinene, all substances with antifungal activity (Bamayi etal., 2004). In vivo, treatment with the essential oil of E. camaldulensis led to a reduction of the severity of anthracnose from 19.16 ± 26.44% for absolute control to 13.41 ± 21.82% for fruits from the field. For the inoculated mangoes, the severity of the disease decreased from 39.44 ± 12.36% (absolute control) to 21.11 ± 6.50% for the treated mangoes. According to Somda et al., (2007), this essential oil is able to inhibit seed- transmitted fungi such as Colletotrichum graminicola, Phoma sorghina and Fusarium moniliforme. Abd-AllA et al. (2013) suggested that the hydrophobic nature of essential oils and their components allow them to penetrate the lipids of the cell membrane and mitochondria of fungi by disrupting their structure. Mangoes inoculated with Colletotrichum gloeosporioides showed a delayed onset of symptoms. This is put in connection with the ability of essential oils to slow down the secretion of enzymes produced by the fungus that are responsible for the stainsnoted on the surface of the mango. According to Kramer-Haimovich et al (2006), the secretion of a significant amount of pectinase lyase, an enzyme capable of inducing maceration of the pectocellulosic wall of the host, would be the cause of the onset of symptoms of anthracnose.

REFERENCES

1. Abd-Alla, M. A., & Haggag, W. F. (2013). Use of Some Essential Oils as Post-harvest Botanical Fungicidesin the Management of Anthracnose Disease of Mango Fruits (*Mangifera indica* L.) caused by *Colletotrichum gloeosporioides* (Penz). International Journal of Agriculture and Forestry, 3(1): 1-6

2. Aprotosoaie, A. C., Spac, A. D., Hancianu, M., Tanasescu, V. F., Dorneanu, V., & Stanescu, U. (2010). The chemical profile of essential oil obtained from fennel (Foeniculum vulgare Mill.). FARMACIA, 58(1). pp.46-54.
3. Arauz, L. F. (2000). Mango Anthracnose: Economic impact and current options for integrated management. Plant Diseases 84(6): 600-611.
4. Bamayi, H., Kolo, L., Okogun, II., & Ijah, U.J.J. (2004). The Antimicrobial activities of methanol exracts of Eucalyptus camaldulensis and Terminalia catappa against some pathogenic microorganisms. Journal of Nigerian Society of Experimental Biology, 16 (2) 106-111.
5. Ba, A. (2014). Utilisation d'extraits de plantes médicinales pour le contrôle in vitro de Colletotrichum gloeosporioides Penz., agent responsable de l'anthracnose de la mangue. Mémoire de fin d'études, biologie végétale, fac. Sciences, 24p-29p.
6. Besombes, C. (2008). Contribution à l'étude des phénomènes d'extraction hydrothermomécanique d'herbes aromatiques. Applications généralisés. Thèse de doctorat. Université de la Rochelle, 289p.
7. Bouhdid, S., Abrini, J., Baudoux, D., Manresa, A., & Zhiri. (2012). Les huiles essentielles de l'origan compactet de la cannelle de Ceylan: pouvoir antibactérien et mécanisme d'action. J Pharm Clin ; 31(3) : 141-148.
8. Cissé, M. M., Diedhiou, P.M., & Mbaye, N. (2020). In vitro antifungal activity of essential oils of aromatic plants of the Senegalese flora on Colletotrichum gloeosporioides (Penz.) Penz and Sacc., the causal agent of mango anthracnose. International Journal of Science, Environment and Technology, Vol. 9, No 3 :301 – 311
9. Cisse, M. M. (2016). Activité antifongique des huiles essentielles de quatre espèces végétales de la flore du Sénégal dans la lutte contre Colletotrichum gloeosporioides (Penz.) Penz. & Sacc., champignon pathogène responsable de l'anthracnose de la mangue (Mangifera indica L.). Mémoire de Master. Spécialité : Phytopharmacie et Protection des Végétaux. Fac. Sciences et Techniques. Univ. Dakar, 71p.
10. Diedhiou, P.M., Mbaye, N., Dramé, A., & Samb, P. I. (2007). Alteration of post-harvest diseases of mango (Mangifera indica L.) through production practices and climatic factors. Afric. J. Biotech. 6(9): 1087-1094.
11. Diedhiou, P. M., Mbaye, N., Faye, R., & Samb, P. I. (2014). Field tests of fungicides against post-harvest rotof mangoes in Senegal. Int. J. Scie. Environ. and Techn., 3 (2) : 597–606.
12. Diop, S. (2018). Diversité des champignons phytopathogènes du manguier (Mangifera indica L.) dans deux zones agroécologique du Sénégal et activité antifongique in vitro d'huiles essentielles Mémoire de Master. Spécialité : Phytopharmacie et Protection des Végétaux. Fac. Sciences et Techniques. Univ. Dakar, 73p.
13. Doumbouya, M., Abo, K., Lepengue, A.N., Camara, B., Kanko, K., Aidara, D., & Koné, D. (2012). Activités comparées in 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 Sciences 50: 3520-3532.
14. FAO. (2019). « FAOSTAT ». database collections, agricultural data. Food and Agricultural Organization. Disponible sur: < http://www.fao.org/faostat/fr/#home >
15. Ghalem, B. R., & Mohamed, B. (2014). Antibacterial activity of essential oil of North West Algerian Eucalyptus camaldulensis against Escherichia coli and Staphylococcus aureus. Journal of Coastal Life Medecine 2(10): 799-804.
16. Glitho, I. A., Ketoh, G. K, & Koumaglo, H.K. (2004), activité insecticide comparée des huiles essentielles de trois espèces du genre cymbopogon (Poaceae). j.soc. Ouest-Africa.chim 018, 21-34.
17. Griffin, S.G., S.G. Wyllie, J.L., Markham & D.N. Leach. (1999).The role of structure and molecular properties of terpenoids in determining their antimicrobial activity. Flavour Fragr. J., 14 (5), 322-332.
18. Hamini-Kadar, N., Hamdane, F., Boutoutaou, R., Kihal, M., Henni, J. E. & (2014). Antifungal activity of clove (Syzygium aromaticum L.) Essential oil against phytopathogenic fungi of Tomato (Solanum lycopersicum L.) in Algeria. J. of Experim. Biol. and Agric. Scie., 2(5): 447-454.
19. Hammer, K.A., Carson, C.F., & Riley T.V. (2003). Antifungal activity of the components of Melaleuca alternifolia (tea tree) oil. J. Appl. Microbiol., 95 (4), 853-860.
20. Sohilait H. J.(2015). Chemical Composition of the Essential Oils in Eugenia caryophylata, Thunb from Amboina Island. Science Journal of Chemistry. Vol. 3, No. 6, pp. 95-99.
21. He, M., M, Du., Fan, M., & Z. Bian. (2007). In vitro activity of eugenol against Candida albicans biofilms. Mycopathologia, 163, 173-143.
22. Kramer-Haimovich, H., Servi, E., Katan, T., Rollins, J., Okon, Y., & Prusky, D. 2006. Effect of Ammonia Production by Colletotrichum gloeosporioides on pelB Activation, Pectate Lyase Secretion, and Fruit Pathogenicity. Appl. Environ. Microbial. 72(2): 1034-1039.
23. Kocić-Tanackov, S. D., & Dimić, G. R. (2013). Antifungal activity of essential oils in the control of food-borne fungi growth and mycotoxin biosynthesis in food. Microbial pathogens and strategies for combating them: science, technology and education (A. Méndez-Vilas, Ed.): 838-849.

24. Gakuubi, M. M., Maina, A. W., & Wagacha, J. M. (2017). Antifungal activity of essential oils of Eucaliptus camaldulensis Dehnh. against selected Fusarium spp International Journal of Microbiology 7p https://doi.org/10.1155/2017/8761610.
25. Mbaye, N. (2006). Inventaire et caractérisation des champignons phytopathogènes responsables de maladies post-récolte des mangues (Mangifera indica L.) produites dans la zone des Niayes du Sénégal : cas des variétés Kent et Keitt, destinées à l'exportation. Thèse 3ème cycle, biologie végétale, fac. Sciences, 121 p.
26. Nelson, S. C. (2008). Cephaleuros Species, the Plant Parasitic Green Algae. Plant Dis.,43.,
27. Oller., & Bender I. 2010. The content of oils in Umbelliferous crop and formaton. Agronomy Research, 8(3), pp.687-696
28. Pandey, A., Yadava, L.P., Manoharan, M., Chauhan, U.K., & Pandey, B.K . (2012a). Effectiveness of cultural parameters on the growth and sporulation of Colletotrichum gloeosporioides causing anthracnose disease of Mango (Mangifera indica l.) OnLine J Biol Sc, 12 : 123-13.
29. Padman, M., & Janardhana, G. R. (2012). Screening for inhibitory activities of essential oils on the growth of Colletotrichum gloeosporioides (Penz.) Penz. & Sacc., the causal agent of leaf spot disease of Murraya koenigii., Archives of Phytopathology And Plant Protection, 45 :13, 1575-1581.
30. Pardo-De la Hoz, C. J., Calderon, C., Rincon, A. M., Cardenas, M., Danies, G., Lopez-Kleine, L., Restrepo,S., & Jimenez, P. (2016). Species from the Colletotrichum acutatum, Colletotrichum boninense and Colletotrichum gloeosporioides species complexes associated with tree tomato and mango crops in Colombia. Plant Pathology, 65, 227-237.
31. Sellamuthu, P.S., Sivakumar, D., Soundy, P., & Korsten, L. (2013). Essential oil vapours suppress the development of anthracnose and enhance defense related and antioxidant enzymes activities I avocado fruit. Postharvest Biology and Technology 81: 66-72.
32. Somda, I., Leth, V., & Sereme, P. (2007). Antifungal effect of Cymbopogon citratus, Eucalyptus camaldulensis and Azadirachta indica oil extracts on Sorghum seed-borne fungi, Asian J. Plant Sci., 6(8): 1182-1189.
33. Stangarlin, J.R., Kuhn, O.J., Assi, L., & Schwan-Estrada, K.R.F. (2011) – Control of plant diseases using extracts from medicinal plants and fungi. , 11.
34. Traore, Ga., & Djoumagan, Salimata. (2018) - Efficacité des extraits de plantes en traitement de la mangue de variété keïtt contre les agents fongiques responsables de la pourriture du fruit. Mémoire de master 42.
35. Vidal, R., Muchembled, J., Deweer, C., Tournant, L., Corroyer, N., & Flammier, S. (2018) – Évaluation de l'intérêt de l'utilisation d'huiles essentielles dans des stratégies de protection des cultures. Innovations Agronomiques 63 (2018), 191-210.
36. Yadegarinia, D., Gachkar, L., Rezaei, MB., Taghizadeh, M., Alipoor, A. S.H., & Rasooli, I. (2006). Biochemichal activities of Iranian Mentha piperita L. and Myrtus communis L. essential oils. Phytochemistry. 67, 1249-1255.
37. Zakaria, L., Juhari, N. Z., Vuaya, S.I., & Anuar., I. S. M. (2015). Molecular Characterization of Colletotrichum Isolates Associated with Anthracnose of Mango Fruit.Sains Malaysiana 44 (5): 651-656.
38. Zani, F.G., Massimo, S., Bianchi, A., Albasini, M., Melegari, G., Vampa, A., Belloti, P., & Mazza. 1991. Studies on the genotoxic properties of essential oils with Bacillus subtilis rec-assay and Salmonella microsome reversion assay. Planta Med. 57:327-241.