proceedings

MDPI

Proceedings

Usage of agricultural DAPfertilizer and *Eucalyptus* essential oils as potential attractants against the Mediterranean fruit fly *Ceratitis capitata* (Tephritidae) †

Insaf Sadraoui-Ajmi[1,2],*NejibBenali [3], Abir Soltani [2], Samira Chaib [4], Essia Limem [5], Slim Jallouli [6], Emna Boushih [2], Abdallah Fajraoui [7] and Jouda Mediouni-Ben Jemâa [2]

1 University of Tunis El Manar, Faculty of Science of Tunis, University El Manar, Tunis, 2092 and Tunisia; insafajmi1992@gmail.com
2 National Agricultural Research Institute of Tunisia (INRAT), LR11INRAT06 Laboratory of Biotechnology Applied to Agriculture, University of Carthage, Tunis, Tunisia; benali_nejib@yahoo.fr
3 Laboratory of Energy, Water, Environment and Processes, (LEEEP), ENIG, University of Gabès, Tunisia. soltany.abyr@gmail.com
4 Department of Natural and Life Sciences, Faculty of Exact Sciences and Natural and Life Sciences, University of Larbi Ben M'Hidi, Oum El Bouaghi 4000 Algeria; chaib_samira@yahoo.com
5 General Directorate of Plant Health and Control of Agricultural Inputs, 30, Alain Savary Street, Tunis, Tunisia; essia.limem@hotmail.com
6 Laboratory of Bioactive Substances, Centre of Biotechnology of Borj-Cedria, BP 901, 2050 Hammam-Lif, Tunisia ; selimjallouli80@gmail.com
7 Regional Direction of the Tunisian Chemical Group (GCT), Gafsa, Tunisia; Fajraoui.abdallah@gct.com.tn
* Correspondence: Insaf Sadraoui Ajmi: insafajmi1992@gmail.com
† Presented at the 1st International Electronic Conference on Entomology (IECE 2021), 1–15 July 2021; Available online: https://iece.sciforum.net/

Abstract: This work aims to develop and evaluate an attractant based on the combination of DAP and Eucalyptus essential oils. Essential oils were isolated by steam distillation from Eucalyptus species and analyzed by GC-MS. About 12 and 22 constituents were identified with 1.8 was the major compounds in crude essential oil and formulations. The adsorption efficacy depends on the abundance of each compound in crude essential oils and the polarity of terpenic components. Results indicated the attractant potential of both essential oils (class III) and that DAP/essential oils formulations accomplished better attractant performance (class IV). Formulations were toxic against medfly adults.

Keywords: Attractant, Di-Ammonium Phosphate , Essential oil , Adsorption

Citation: Sadraoui-Ajmi, I.; Benali, N.; Soltani, A; Chaib, S.; Limem, E.; Jallouli, S.; Boushih, E.; Fajraoui, A.; Mediouni-Ben Jemâa, J. Usage of agricultural DAP fertilizer and *Eucalyptus* essential oils as potential attractants against the Mediterranean fruit fly *Ceratitis capitata* (Tephritidae), in Proceedings of the 1st International Electronic Conference on Entomology, 1–15 July 2021, MDPI: Basel, Switzerland, doi:10.3390/IECE-10392

Published: 30 June 2021

Publisher's Note: MDPI stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Copyright: © 2021by the authors. Submitted for possible open access publication under the terms and conditions of the Creative Commons Attribution (CC BY) license (http://creativecommons.org/licenses/by/4.0/).

1.Introduction

Medfly*Ceratitis capitata* (Wiedemann) (Diptera: Tephritidae), is among the major destructive pests of fruits worldwide, particularly in the Mediterranean regions [1,2].In Tunisia, Medfly is a key economic pest on citrus and various crops [3]. Current control program is mainly based on applications insecticides [4].However, their use is subject to much controversy [5].In this respect, botanical extracts and essential oils could be suggested as alternatives[6]. Many essential oils are particularly known for their important insecticidal, pesticidal and repellent/attractant properties. [7]. Usually, the use of attractants is associated with procedure in which the pest is displaced from a protected resource (crops, fruits, area …) and concurrently lured [8]. In this respect, it has been demonstrated that plant essential oils could act as insect attractant [9]. Indeed, various studies have been cited on attractant potential of eucalyptus essential oils against Dipdipteran pests [10,11,12]. On the other hand, Tunisia is ranked among largest phosphate rock producer in the world [13].Fertilizers presented the major inputs in modern

agricultural production since they increased crops yields and improve sol fertility [14]. Besides, Di-Ammonium Phosphate exhibited an attractive activity towards *C. capitata* adults [15].This paper reports the chemical composition, attractant potential and contact toxicity of two crude *Eucalyptus* essential oils (*E. cinerea*F. Muell and *E. maidenii* F. Muell) and their formulations by adsorption onto DAP fertilizers against *C. capitata*.

2. Materiel and methods

2.1. Insect rearing

To initiate *C. capitata* rearing, infested fruits were collected from various fields (orange, mandarin, clementin,...) of Gafsa oasis (34°23′N, 8°48′E). Rearing was conducted under the following controlled laboratory conditions: 30 ± 1 °C, 65 ± 5% RH and a continuous light [16].

2.2. Plant materials

Eucalyptus maidenii and *E. cinerea*aerial parts were collected in April 2019 from Souinet arboretum Ain Draham, northwestern Tunisia (36°47′N 8°42′E). The harvested materials were air-dried at room temperature (20-25 °C) for one week

2.3. Extraction, analysis and adsorption of essential oils

100 g of dry plant material was subjected to hydrodistillation for 180 min in a Clevenger-type apparatus in accordance with European Pharmacopoeia method [17].The distilled essential oils were stored in a refrigerator at 4 °C until being analyzed and used. The analysis of the chemical composition of essential oils was realized by 6980 N Network GC system equipped with -5MS.

The adsorption percentage (%R) at an instant was calculated using the relation described by [18]: $\%R = \frac{C0-Ct}{C0}100$ (1), Ct: is the concentration of adsorbate at time t; C 0 is the concentration initial.

2.4. Fertilizers characterization: Ray Diffraction analysis (XRD)

The powder X-Ray Diffraction patterns of the DAP fertilizer were measured using Panalytical (X'pertPro) diffractometer equipped with a copper anticathode ((λ = 1.54178 Å)

2.5. Repellency bioassay (Filter Paper Tests)

The repellent bioassay was evaluated against *C. capitata* adults, using the protocol described by [19]. The percent repellency (PR) was calculated according to [20].

2.6. Data analysis

Statistical analysis was performed using SPSS statistical software version 20.0. Data were subjected to two-way ANOVA. All obtained values were the mean of three replications and were expressed as the mean ± standard error. Differences in values of each oil treatments were tested by ANNOVA one way followed by Duncan test. Statistical analysis was conducted to estimate repellent concentrations (RC_{50} and RC_{95}) (Concentrations that repelled 50 and 95% of the exposed insects). Furthermore, bioassays were considered to calculate respectively lethal concentrations LC50 and LC95 (doses that kill 50% and 95% of exposed insects).

3. Results

3.1. Essential oil composition

The chemical composition of essential oils extracted from Eucalyptus species (*E. cinerea*and *E. maidenii*) was presented in Table 1.

Table 1. Chemical composition (%, µg/µL) of volatile compounds of *Eucalyptus cinerea* and *Eucalyptus maidenii* essential oils

			Eucalyptus cinerea		***Eucalyptus maidenii***	
N°	**Compounds**	**RT**	**%**	**C_{x1} (µg/uL)**	**%**	**C_{x1} (µg/uL)**
1	α-Pinene	6.43	**6.436**	**0.268**	**10.344**	**0.432**
6	1,8-Cineole	9.027	**74.586**	**3.103**	**66.708**	**2.783**
13	α-Terpineol	13.461	**2.762**	**0.115**	**7.376**	**0.307**
15	Camphene	17.789	**10.864**	0.452	**0.223**	**0.009**

Results showed that qualitatively, *E. cinerea*and *E. maidenii* oils were found to possess similar compositions. The major common constituents were 1,8-cineole, α pinene, α-terpineol and camphene (Table 1).

3.2. X-Ray Diffraction analysis of DAP Fertilizer

The Diffractogram X-Ray presents characteristic peaks of pure DAP (Figure 1).

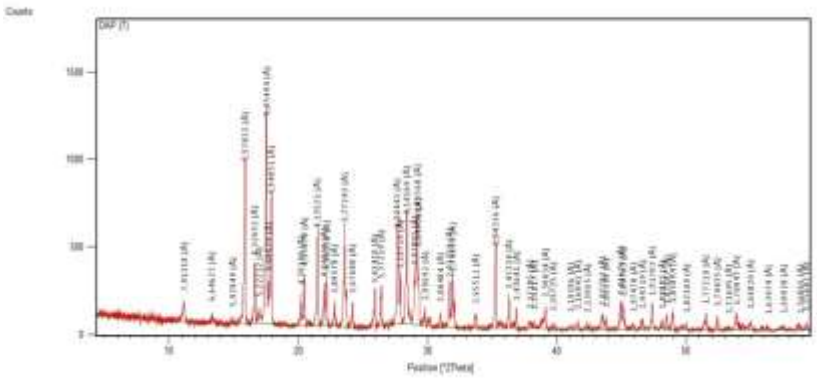

Figure 1. XRD Spectra of Diammonium Phosphate (DAP) Fertilizer .

The results revealed that in DAP sample, the main compound identified is (NH4)2HPO4. The Diffractogram indicated three peaks at the diffraction angle 2θ=17.424 (d-spacing = 5.0549 Å), 16.8432 (d-spacing = 5.5783 Å) and 17.8961 (d-spacing = 4.9485 Å).

3.3. Repellent/ Attractant proprieties

The percentage repellency (PR) and indices repellency (IR) values of the crude essential oils and DAP/ essential oils based formulations against adults of *C. capitata* after 24 h exposure are given in (Table 2).

Table 2. Repellency (%) of essential oilsfrom *Eucalyptus cinerea* and *Eucalyptus maidenii* against adults of *Ceratitis capitata*.

		Treatments	**Concentrationµl/cm²**	**PR**	**Repellency class**	**IR**
Essential oils		*Eucalyptus cinerea*	0.000039	-20	I	1.20
			0.00007	-40	II	1.40
			0.00011	-46.66	III	1.53
		Average repellency		-35.53	II	1.37
		Eucalyptus maidenii	0.000039	-26.66	II	1.40
			0.00007	-40	II	1.40
			0.00011	-60	III	1.60
		Average repellency		-42.22	III	1.46
Formulations DAP/ Essential oils		Crude DAP	30 mg	-20	I	1.20
		DAP/*Eucalyptus cinerea*	110.52mg	-66.66	IV	1.66
		DAP/*Eucalyptus maidenii*	20.31mg	-73.33	IV	1.73

It is deduced from this that the attractant effect (%) increased with the augmentation of essential oil concentration.According to [21] classification, negative Figs expressed attractancy. Consequently, both crude *E. cinerea*and *E. maidenii*oils were attractant towards

C. capitata adults. The average repellent effect of this crude oil was low attractant PR = -35.33% (class II) for E. cinerea and attractant effect (PR= -42.22%) class III. For both formulations, attractiveness activity belongs to class IV. Besides, for DAP, results showed that this fertilizer exhibited very low attractant effect (class I).

4. Discussion

In agreement with most cited documents, 1,8-cineole was the major compound identified in *Eucalyptus* oils [22,23,24]. Our data provides clear evidence that both essential oils were rich in compounds known to possess insecticidal activity [22-25]. Diverse reports documented that *Eucalyptus* oils exhibited high attractant and contact toxicity potential against various insects [26,27,28]. Based on this study, a synergy in the attractant efficacy of the formulations DAP/ essential oils from *E. cinerea* and *E. maidenii* was observed. The direct impact of these formulations was the improvement of DAP attractance against *C. capitata*. Indeed, crude DAP revealed very low attractant effect (class I) towards Medfly adults; while; with DAP/ essential oils formulations, attractant potential reached attractant level (class IV). The improvement of DAP/essential oil formulation attractiveness could be attributed to the insecticidal potential of essential oils previous studies pointed out the toxic effects of DAP/Eucalyptus essential oils formulations against Medfly adults.

5. Conclusion

Results from this work revealed that formulations based on the combined use of agricultural fertilizer (Di-Ammonium Phosphate) and essential oils (*Eucalyptus* oils) could be involved as a component for Medfly control strategy in oasis. This could be proposed amid current methods for an IPM approach.

Author contribution： Insaf Sadraoui Ajmi, Nejib Benali and Abir Soltani conceived, designed the experiments and wrote the manuscript with input from all authors. Emna Boushih worked for insect rearing and performed the extraction of essential oils. Selim Jallouli achieved the GC-MS analysis of the essential oils. Fajraoui Abdallah and Samira Chaib provided critical feedback on the manuscript. Essia Limem helped on fruit sampling. Jouda Mediouni Ben Jemâa devised the project, the main conceptual ideas and proof outline. All authors discussed and commented the manuscript.

Funding :"This research was funded by "MOBIDOC Promess", program of the Tunisian Ministry of Higher Education and Scientific Research, ANPR grant number 191/2019".

Acknowledgements: Authors thank Ms. Emna BOUSHIH for her technical support in the laboratory experiments.

Conflicts of Interest: "The authors declare no conflict of interest".

References

1 Aluja, M., Mangan, R.L. Fruit fly (Diptera: Tephritidae) host status determination: critical conceptual, methodological, and regulatory considerations. *Annu. Rev. Entomol* **2008**, *53*, 473-502.

2 Staub, C.G., De Lima, F., Majer, J.D. Determination of host status of citrus fruits against the Mediterranean fruit fly, Ceratitis capitata (Wiedemann)(Diptera: Tephritidae). *Aust. J. Entomo* **2016**; *47*, 184-187.

3 Jerraya, A. Principaux nuisibles des plantes cultivées et des denrées stockées en Afrique du Nord: leur biologie, leurs ennemis naturels, leurs dégâts et leur contrôle. Maghreb Editions, Tunisia **2003**; 415pp.

4 Boussabbeh, M., Salem, I.B., Hamdi, M., Fradj, S.B., Abid-Essefi, S., Bacha, H. Diazinon, an organophosphate pesticide, induces oxidative stress and genotoxicity in cells deriving from large intestine. *Environ. Sci. Pollut. Res* **2016** ; *23*: 2882-2889.

5 Jemâa, J.M.B., Bachrouch, O., Allimi, E., Dhouibi, M. Field evaluatin of Mediterranean fruit fly mass trapping with Tripack as alternative to malathion bait-spraying in citrus orchards. Spanish Journal of Agricultural Research **2010**; 400-408.

6 Barton, A. The oil mallee project: a multifaceted industrial ecology case study. *J. Ind.Ecol* **1999**, *3*, 161-176.

7 Regnault-Roger, C., Vincent, C., Arnason, J.T. Essential oils in insect control: low-risk products in a high-stakes world. Annu.Rev. Entomol, 2012; 57, 405-424.

8 Nalyanya, G., Moore, C.B., Schal, C. Integration of repellents, attractants, and insecticides in a" Push-pull" strategy for managing German cockroach (Dictyoptera: Blattellidae) populations J Med Entomol **2000**; 37, 427-434.

9 Mwatawala, M., Virgilio, M., Quilici, S., Dominic, M., De Meyer, M. Field evaluation of the relative attractiveness of enriched ginger root oil (EGO) lure and trimedlure for African C eratitis species (D iptera: T ephritidae). *Journal of Applied Entomology* **2013**; 137, 392-397.

10 Robacker, D., Warfield, W., Flath, R. A four-component attractant for the Mexican fruit fly, Anastrephaludens (Diptera: Tephritidae), from host fruit. *Journal of chemical ecology* 1992; 18, 1239-1254.

11 Malheiro, R., Ortiz, A., Casal, S., Baptista, P., Pereira, J.A. Electrophysiological response of Bactroceraoleae (Rossi) (Diptera: Tephritidae) adults to olive leaves essential oils from different cultivars and olive tree volatiles. *Ind. Crops. Prod* **2015**; 77, 81-88.

12 Diongue, A., Yen, T.B., Lai, P.-Y. Bioassay studies on the effect of essential oils on the female oriental fruit fly, Bactroceradorsalis (Hendel)(Diptera: Tephritidae). *Pest Management In Horticultural Ecosystems* **2010**; 16, 91-102.

13 Anonymous. Annual report, GroupeChimiqueTunisien **2014**.

14 Aziz S, Yaseen L, Jamal A, FarooqU, Qureshi Z, Tauseef I, et al. Fabrication of Biochar from Organic Wastes and its Effect on Wheat Growth and Soil Microflora. *Pol. J. Environ. Stud* **2020**; 29: 1069–1076.

15 Trabelsi I, B.K.S., and Jrad F. Performances des attractifs alimentaires synthétiques acétate d'ammonium, triméthylamine et putrescine formulés en Tripack® dans le piégeage de la mouche méditerranéenne des fruits (Diptera: Tephritidae). Regional Symposium on the Management of Fruit Flies in Near East Countries.**2012** November 6-8 Hammamet, Tunisia, (2012).

16 Cheikh, M. Elevage massif de la mouche mediterraneenne des fruits Ceratitis capitata Wied. (Dipt.Tryp), **1977**.

17 Europe, C.o. European pharmacopoeia. 3rd ed., Strasbourg , France: Council of Europe, **1997**.

18 Abechi, E., Gimba, C., Uzairu, A., Kagbu, J. Kinetics of adsorption of methylene blue onto activated carbon prepared from palm kernel shell. *Archives of Applied Science Research* **2011**; *3*, 154-164.

19 Maazoun, A.M., Hamdi, S.H., Belhadj, F., Jemâa, J.M.B., Messaoud, C., Marzouki, M.N.. Phytochemical profile and insecticidal activity of Agave americana leaf extract towards Sitophilus oryzae (L.) (Coleoptera: Curculionidae). *Environmental Science and Pollution Research* **2019**; *26*, 19468-19480.

20 Jemâa, J.M.B., Tersim, N., Toudert, K.T., Khouja, M.L. Insecticidal activities of essential oils from leaves of Laurus nobilis L. from Tunisia, Algeria and Morocco, and comparative chemical composition. *Journal of Stored Products Research* ***2012b***; *48*, 97-104.

21 McDonald, L.L., Guy, R.H., Speirs, R.D. Preliminary evaluation of new candidate materials as toxicants, repellents, and attractants against stored-product insects. *US Agricultural Research Service* **1970**.

22 Batish, D.R., Singh, H.P., Kohli, R.K., Kaur, S. Eucalyptus essential oil as a natural pesticide.*Forest Ecology and Management* **2008**; *256*, 2166-2174.

23 Liu, X., Chen, Q., Wang, Z., Xie, L., Xu, Z. Allelopathic effects of essential oil from *Eucalyptus grandis*× *E. urophylla* on pathogenic fungi and pest insects. *Frontiers of Forestry in China* **2008**; 3, 232-236.

24 Sebei, K., Sakouhi, F., Herchi, W., Khouja, M.L., Boukhchina, S. Chemical composition and antibacterial activities of seven Eucalyptus species essential oils leaves. *Biological research* **2015**; 48, 1-5.

25 Yang, Y.-C., Lee, H.-S., Clark, J., Ahn, Y.-J. Insecticidal activity of plant essential oils against Pediculushumanuscapitis (Anoplura: Pediculidae). *Journal of medical entomology* **2004**; *41*, 699-704.

26 Robacker, D.C. Attractiveness to Anastrephaludens (Diptera: Tephritidae) of plant essential oils and a synthetic food-odour lure. *Journal of Applied Entomology* **2007**; *131*, 202-208.

27 Palacios, S.M., Bertoni, A., Rossi, Y., Santander, R., Urzúa, A. Insecticidal activity of essential oils from native medicinal plants of Central Argentina against the house fly, Muscadomestica (L.). *Parasitology Research*, 2009; 106, 207-212.

28 Cavalca, P.A.M., Lolis, M.I.G.d.A., Reis, B., Bonato, C.M. Homeopathic and larvicide effect of Eucalyptus cinerea essential oil against Aedesaegypti. *Brazilian Archives of Biology and Technology* **2010**; *53*, 835-843.