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Research Article

# Phytotoxic potential of essential oil of *Melaleuca leucadendra* against some agricultural weeds

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**Abstract**: The work was undertaken to investigate the phytotoxic potential of essential oil from *Melaleuca leucadendra* against three weed species, *viz*., *Echinochloa crus-galli*, *Cyperus rotundus* and *Leptochloa chinensis*. It was observed that volatile oil (0.25-1.5 mg ml$^{-1}$) of *Melaleuca* retarded the germination and growth of all the test weeds in a dose-response bioassay conducted under laboratory conditions. Generally, both root and shoot length showed an inhibitory effect in a concentration dependent manner and the maximum effect was observed in *C. rotundus*, followed by *E. crus-galli* and *L. chinensis*. The *Melaleuca* oil not only affected the germination and seedling growth of the test weeds, but also inhibited the chlorophyll content and dry weight. At the highest dose of *Melaleuca* oil treatment (1.5 mg ml$^{-1}$), the chlorophyll content declined by nearly 50% in *E. crus-galli* and 90% in *L. chinensis* over the control. Thus, it is concluded that volatile oil possesses phytotoxic potential towards other plants and could be further explored for weed management.

**Keywords:** Phytotoxicity, Weed management, *Melaleuca leucadendra*, Growth inhibition

## Introduction

A large number of aromatic plants possessing naturally occurring substances have been in use since ancient times. Essential oils form one such class of natural products which find utility in various products such as in foods, cosmetics, medicines, as antimicrobial/ insecticidal agents, insect repellants (Dorman and Deans, 2000; Isman and Machial, 2006; Bakkali *et al*., 2008). These functional elements are earning importance these days because of the negative health effect associated with the use of synthetic products. Nowadays, scientists have shown considerable interest in the phytotoxic potential of different essential oils. The essential oils extracted from aromatic plants are becoming popular with the potential to control weeds because of their structural and chemical diversity (Singh *et al*., 2003; Bakkali *et al*., 2008; Duke and Dayan, 2015). Due to the important benefits of essential oil including biodegradable nature (Zygadlo and Grosso, 1995), ecofriendly behavior, minimum mammalian toxicity (Dayan *et al*., 2012), short environmental half-lives, tendency to affect novel target sites (Grana *et al*., 2013) and impersistent in soil and water (Isman, 2006), they have the potential to be used as bio-herbicides (Batish *et al*., 2008; Pinheiro *et al*., 2015; Grichi *et al*., 2016). In view of phytotoxicity and weed suppressing ability of volatile essential oils and their constituents against weeds, it is thus pertinent to study the aromatic plant to scrutinize its phytotoxic ability with an aim of using them for weed management.

*Melaleuca leucadendra*, commonly called as Cajuput tree, is native to Australia and Southeast Asia. It is moderately fast growing perennial evergreen tree, and mainly occurs near river flats, coastal plains or seasonal swamps (Anonymous, 2003). It is cultivated in parks and gardens as an ornamental tree. It has bright green foliage, straight and long flexible trunk with pendulous branching and spongy lamellate bark. The inflorescence is terminal and dense flowers occur in triads. The plant is used for various purposes such as timber, mulch and its essential oil as a source of medicine (Bodle, 1998). Volatile oil of tea tree plant is used to cure the acne problem (Bassett *et al*., 1990), dandruff (Satchell *et al*., 2002) and oral candidiasis (Vazquez and Zawawi, 2002). It also possesses a number of biological activities including antitermite (Sakasegawa *et al*., 2003), antiviral (Cleber *et al*., 2007) and antifungal activities (Lee *et al*., 2008). Pujiarti *et al.* (2012) reported bioactive potential of the leaf oil components exhibiting antioxidant, anti-hyaluronidase and antifungal activities. However, the information regarding the phytotoxicity of *M. leucadendra* oil towards weeds is largely lacking. Therefore, the present study was planned to assess the phytotoxicity of volatile essential oil from *M. leucadendra.*

## Materials and Methods

**Plant material:** *Melaleuca leucadendra* is a perennial plant, found in parks and gardens in India. Leaves of the plant were collected from the Botanical Garden of Panjab University campus, Chandigarh, India.

**Essential oil extraction:** The essential oil was extracted from the plant material (leaves) by steam

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distillation process using Clevenger's apparatus. Nearly two kg of freshly collected plant material was mixed with 1 L of water. The mixture was boiled for 3 h and the oil was collected from the nozzle of the condenser. The obtained essential oil was dried over anhydrous sodium sulphate and stored at 4$^{O}$C until tested.

**Collection of seeds:** Seeds of the weeds, *Echinochloa crus-galli* (L.) Beauv., *Cyperus rotundus* L., and *Leptochloa chinensis* (L.) Nees were collected from the wild stands growing abundantly in and around Panjab University campus, Chandigarh. The test weeds were selected as they are economically important, troublesome and commonly found in agriculture fields.

**Growth bioassay:** Viable and healthy seeds of the test weeds were scarified individually with 2 % sodium hypochlorite for 2 min followed by rinsing with distilled water and finally imbibed in distilled water for 24 h. For their treatment in solution form, various concentrations (0.25–1.5 mg/ml) were prepared by dissolving oil in water with the help of Tween-20. Petri dishes of 15 cm were lined with two layers of Whatman No. 1 filter circle and was moistened with 10 ml of different oil concentrations (Batish *et al.*, 2004). After 7 days of treatment, growth of test weeds was measured in terms of percent germination and seedling growth (root length and shoot length) under laboratory conditions. Leaves of test plants were taken for chlorophyll content estimation.

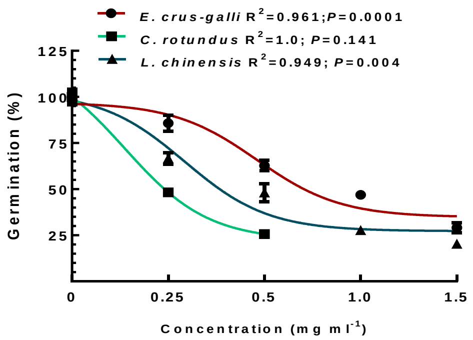
**Estimation of total chlorophyll content:** The total chlorophyll content from the leaves of the test species was extracted in dimethyl sulphoxide (DMSO) following the method of Hiscox and Israelstam (1979). The extinction value of chlorophyll extracted in DMSO was measured at a dual wavelength of 645 and 663 nm on Shimadzu UV- 1800 double beam spectrophotometer, using DMSO as blank. The amount of chlorophyll was calculated using the Arnon's equation (1949). It was expressed in μg mg$^{-1}$ dry weight (DW) of the tissue as suggested by Rani and Kohli (1991).

**Statistical analysis:** The statistical analysis of data was done using one-way analysis of variance followed by separation of treatment means from the control by using *post hoc* Tukey's test at $P \leq 0.05$ significance level using software program SPSS (Version 16.0).

## Results and Discussion

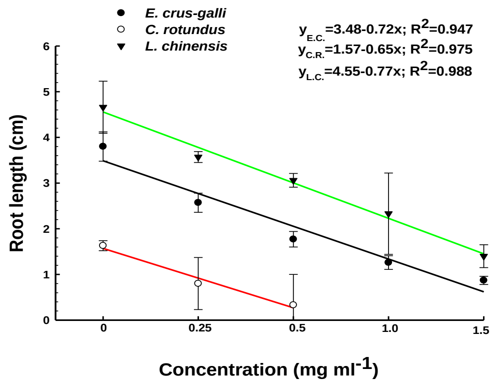
The germination of all the test weeds was significantly reduced in a concentration-dependent manner. At lower concentration (0.25 mg ml$^{-1}$) of oil, minimum inhibition in germination of the weeds (14.24% in *E. crus-galli*, 51.67% in *C. rotundus* and 33.33% in *L. chinensis*) over the control was noticed (Fig. 1). The reduction was greater with increasing amount of *Melaleuca* oil. At highest concentration (1.5 mg ml$^{-1}$), maximum inhibition was noticed in *C. rotundus* (100%) followed by *L. chinensis* (79.63%), *and E. crus-galli* (70.87%) over the control (Fig. 1). The observations made in the present study are parallel to earlier studies documenting the inhibition of seed germination in response to essential oils (Singh *et al.*, 2009; Grichi *et al.*, 2016; Ricci *et al.*, 2017). From the previous studies, it has been known that the essential oil exhibited potent inhibitory effect on germination and growth, and causing morphological and physiological changes in the plant seedlings (Kordali *et al.*, 2015; Bali *et al.*, 2016). The mechanism of the inhibitory action of essential oils remains unclear, although it has been reported that essential oil, mainly their constituent's monoterpenes, inhibit the cell division of apical meristems (Nishida *et al.*, 2005; Singh *et al.*, 2009).

**Fig.1:** Effect of *M. leucadendra* oil on germination (%) of test weeds measured after 7 days of exposure.



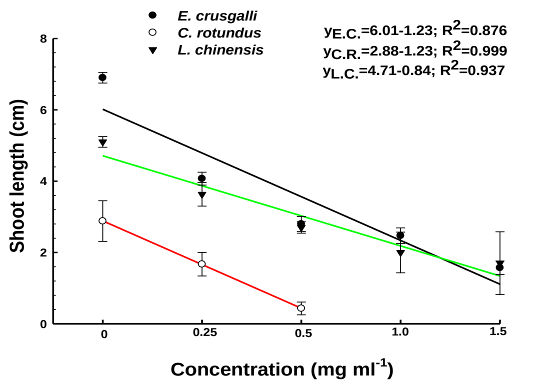

Data represented as mean±SE and analysed by linear regression; $R^2$ represents coefficient of determination; Data is significant for all weeds at $P \leq 0.05$ except for *C. rotundus*

**Fig.2:** Effect of *M. leucadendra* oil on root length (cm) of test weeds measured after 7 days of exposure.



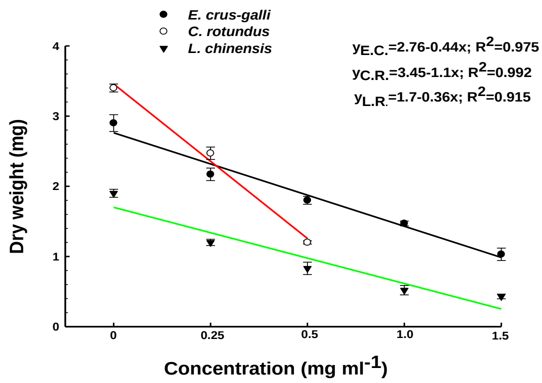

Data represented as mean±S.E. Data analysed by linear regression; $R^2$ represents coefficient of determination; Data is significant for all the weeds at $P \leq 0.05$ except for *C. rotundus*.

**Fig. 3:** Effect of *M. leucadendra* oil on shoot length (cm) of test weeds measured after 7 days of exposure.



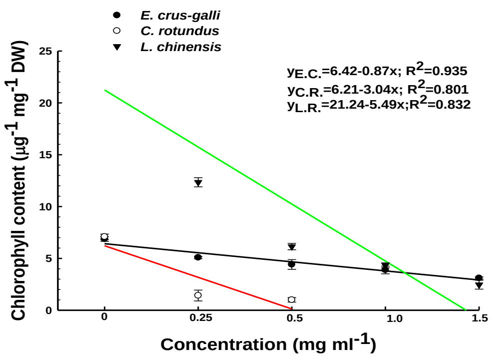

Data represented as mean±S.E. Data analysed by linear regression; $R^2$ represents coefficient of determination; Data is significant for all the weeds at $P \leq 0.05$.

**Fig. 4:** Effect of *M. leucadendra* oil on dry weight (mg) of test weeds measured after 7 days of exposure.




Data represented as mean±S.E. Data analysed by linear regression; $R^2$ represents coefficient of determination; Data is significant for all the weeds at $P \leq 0.05$.

**Fig. 5:** Effect of *M. leucadendra* oil on total chlorophyll content (µg mg$^{-1}$ DW) of test weeds measured after 7 days of exposure.




Data represented as mean±S.E. Data analysed by linear regression; $R^2$ represents coefficient of determination; Data is significant for all the weeds at $P \leq 0.05$ except for *C. rotundus*.

Further, seedling growth measured in terms of root and shoot length in the test weeds declined in a dose dependent manner in response to *Melaleuca* oil treatment. A significant reduction in the root length ranging from ~33 to 77% in *E. crus-galli*, 23 to 70% in *L. chinensis* and 51 to 100% in *C. rotundus* over the control was observed in response to 0.25-1.5 mg ml$^{-1}$ of *Melaleuca* oil (Fig. 2). The reduction was greater with an increase in the amount of *Melaleuca* oil. Likewise, the shoot length of test weeds was significantly reduced in response to *Melaleuca* oil. It was reduced by nearly 41%, 59%, 64% and 77% at 0.25, 0.5, 1.0, 1.5 mg ml$^{-1}$ respectively over that of control in *E. crus-galli* (Fig. 3). The shoot length in *C. rotundus* also declined significantly upon exposure to different concentration of oil. It decreased by nearly 42%, 89% and 100% at 0.25, 0.5, 1.0 mg ml$^{-1}$, respectively, over the control (Fig. 3). In case of *L. chinensis*, shoot length declined significantly by 29%, 47%, 61% and 66% at 0.25, 0.5, 1.0, 1.5 mg ml$^{-1}$ of the oil over that in the control (Fig. 3). The growth retardatory effects of *Melaleuca* oil on the test plants is in agreement with earlier studies reporting inhibitory effect of volatile oils from aromatic plants on the seedling growth of weeds (Singh *et al.*, 2009; Rolli *et al.*, 2014, Arora *et al.*, 2016; Ricci *et al.*, 2017). The reduction in early growth of weeds could be due to the inhibitory effect of plant volatiles on the cell division and lowered root mitotic activity, DNA synthesis of growing root tips and disruption of the membranes (Nishida *et al.*, 2005; Ahuja *et al.*, 2015). The effect might be attributed either to high percent of main constituent or to synergy among different oil constituents.

The dry weight of all the test weed seedlings decreased significantly in response to *Melaleuca* oil treatment. The percent reduction in dry weight varied from species to species. The dry weight of *E. crus-galli*, *C. rotundus* and *L. chinensis* declined by ~ 25-64%, 27-100% and 37-77% respectively, in response to *Melaleuca* oil (0.25-1.5 mg ml$^{-1}$) over the control (Fig. 4). A loss in weight of the plants could be possibly due to the accumulation of less carbon in the plant (Batish *et al.*, 2007).

Further, chlorophyll content declined upon exposure to different concentrations of *Melaleuca* oil. The decline in total chlorophyll content was observed in all the test weeds in a dose-dependent manner. At highest concentration of 1.5 mg ml$^{-1}$ of *Melaleuca* oil, the chlorophyll content declined by 55% in *E. crus-galli* and 90% in *L. chinensis* over the control (Fig. 5). Among the weeds, *C. rotundus* was the most affected followed by *L. chinensis* and *E. crus-galli*. The observation made in the present study is in parallel to previous reports where volatile allelochemicals were found to decrease the chlorophyll content in the plants and consequently interferes with the photosynthetic activity of the plants (Batish *et al.*, 2004; Kaur *et al.*, 2010; Araniti *et al.*, 2017). Although the exact cause of decrease in the total chlorophyll content is not known, it could be either due to inhibition of chlorophyll synthesis or enhanced chlorophyll degradation or both (Yang *et al*., 2004; Chowhan *et al*., 2013).

## Conclusion

From the present study, it could be concluded that *Melaleuca* oil exhibits phytotoxic activity towards all the test weeds by suppressing the germination and early seedling growth of the test plants. Therefore, it holds good potential to be useful for developing natural herbicides.

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