

1 **Use of essential oils of cinnamon (*Cinnamomum zeylanicum* L.), lavender**
2 **(*Lavandula* spp.) and peppermint (*Mentha x piperita* L.) for weed control**

3
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9
10 **Abstract**

11 The indiscriminate use of synthetic chemical compounds for weed control has been
12 often responsible of damage to both the environment and the human health. To
13 challenge these problems, in the last years research has increased its effort to find out
14 alternatives farming strategies. A feasible alternative could be the identification of
15 natural substances with allelopathic effects for the realization of natural herbicides.
16 Some research has already highlighted the possibility of using essential oils, extracted
17 from aromatic plants, for weed control. The advantage in the utilization of such natural
18 compounds is the quickly breaking down process into the environment and so the
19 possible application in sustainable agriculture like organic farming. Objective of this
20 research was the evaluation of the inhibition effect exerted by the essential oils of
21 cinnamon, peppermint and lavender on seeds germination of some of the most common
22 weeds species of the Mediterranean environment (pigweed, wild mustard and ryegrass).
23 The results have highlighted a control in the weeds germination. Among the essential
24 oils tested, cinnamon oil has exerted the highest inhibition effect compared with
25 lavender and peppermint ones. The dicotyledonous species have been more susceptible

compared with the monocotyledonous, even if it has been recorded only for redroot pigweed a dose able to inhibit totally the seed germination.

Key words: allelopathy, essential oils, natural herbicides

Introduction

The approach to the agriculture activity in the last years has changed. The great interests in sustainable and organic agriculture have lead research and studies on a different path from the past, more focused on ecology, environment and human health instead than basic production (Anaya, 1999). The research activity in the last years has centered its attention mainly towards Integrated Weed Management System (IWMS) rather than chemical, so the ability of controlling weeds by mean of agronomic choice and natural ways could have a wider and valuable application. In this view of multifunctional approach, some species of agricultural interest already known for their allelopathic effects could be used as weed management tools.

The search for sustainable and environmentally friendly farming methods has already renewed the interest in the use of allelopathy, which has been widely reviewed (Molisch, 1937; Rice, 1984; Duke & Abbas, 1995; Dukes *et al.*, 1996, 1997, 1998). Potentially plants are able to produce allelochemicals compounds, but more studies have to be pursued to understand the interactions occurring in the field and the possible agronomic applications. Many plant species have been studied for their allelopathic potential; in particular aromatic plants have been reported being able to produce a large amount of allelochemicals. They have frequently been described for these features (Sigmund, 1924; Went, 1942; Bonner, 1950; Muller, 1986) and in particular Muller *et*

al., (1964) observed that in the surroundings of aromatic shrubs there were no annual plants in a diameter of 90 cm. So, the ability to suppress weeds by means of essential oils extracted from aromatic plants could be a valuable tool for weed control. Some research has already highlighted the inhibition of seed germination by means of essential oil. Different inhibition potential of essential oils on seed germination was noticed by Dudai (1999) and Tworkoski (2002). The inhibition ability exerted by cinnamon was observed by Tworkoski who compared several essential oils and recorded the stronger ability of cinnamon among the others. The higher inhibition ability of peppermint on lavender, instead, was observed by Dudai (1999) who noticed the higher inhibition ability of peppermint essential oil on lavender essential oil fixing the I_{50} (50% inhibition of germination) dose for peppermint almost at the half of the one for lavender. Differences in sensitivity among weeds is highlighted by other authors (Dudai, 1999; Tworkoski, 2002; Mao, 2004) which observed differences in dose requirement of the same oil to inhibit the seed germination of different species. The aim of this research was to investigate the potential effect of cinnamon, peppermint and lavender essential oils as a natural herbicide against the germination in the soil of some common weeds.

Materials and methods

The research was carried out in plastic pots of 400 ml (10 cm diameter, 8 cm height) in greenhouse (controlled temperature 25 °C during the day, and 15 °C during the night) to test the effect of the inhibition ability of the essential oils of cinnamon (*Cinnamomum zeylanicum* L.), lavender (*Lavandula* spp.) and peppermint (*Mentha x piperita* L.) on the seed germination of some common weed species present in the Mediterranean

environment, such as redroot pigweed (*Amarantus retroflexus* L.), wild mustard (*Sinapis arvensis* L.) and ryegrass (*Lolium* spp.). To remove the dormancy and synchronize the germination, before starting the test, all the seeds were put into the germination chamber at a temperature of 5 °C in the dark for two days. Before the trial, the soil was put into the oven at a temperature of 104 °C until constant weight. In each pot filled with 0.5 kg of loamy soil, 25 seeds of each weed were sown at a depth of 4 mm. For each essential oil, the oil-in-water emulsion was prepared at the concentration of 5.4 – 21.6 – 86.4 and 345.6 mg l⁻¹ named as C1, C2, C3 and C4, respectively. The essential oils utilized were pure at 100%. An emulsion of 5 ml was sprayed on the soil surface of each pot (area of 78 cm²). A control utilizing only water was performed as test for the maximum percentage of germination. Each treatment, including controls, was replicated three times. The essential oil-in-water emulsion was sprayed on the soil surface just after the sowing; the daily irrigation was made only with water gently sprayed on the soil until it got humid without water leaching from the pot. Every day since the sowing date for 4 weeks the seedling emergence was directly observed and recorded. It was considered as germinated a seed from which a radicle emerged. Relative germination was calculated as the germination of the treatment divided by that of the corresponding control. Analysis of variance was performed to evaluate the effect of essential oil concentrations adopting the ANOVA procedures, while a regression analysis was performed between seedling emergency and concentration using the SAS program.

Results and Discussion

The use of essential oils has generally **determined** a reduction of the seed emergence compared with the control with pure water (C0) since the start of the trials. The reduction of the germination appeared noteworthy already at the minimum concentration (C1). Among the essential oils tested, cinnamon have exerted the higher inhibition ability with a reduction of the germination compared with the control of the 40%, 52% and 48% respectively for ryegrass, wild mustard and redroot pigweed (Fig. 1 – 2 – 3). Inhibition ability has been observed anyway at the lower concentration of lavender (C1) and peppermint (C1) for redroot pigweed and wild mustard, while ryegrass resulted being less susceptible with these oils. The results showed that there is not always a dose-dependent relation between oil concentrations and inhibition ability. Using the C2 oil concentration has been observed the same trend exerted by the C1 (Fig. 1 – 2 – 3). Increasing additionally the concentration (C3), instead, the inhibition activity generally raised. Compared with the control (C0) cinnamon oil inhibited almost totally redroot pigweed (92%), while ryegrass and wild mustard were inhibited for the 45% and 49%. Lavender oil inhibited ryegrass (45%), wild mustard (57%) and redroot pigweed (77%) following the same trend. Peppermint showed instead an unexplainable activity. At the C3 concentration exerted the maximum inhibitory activity for ryegrass (62%), and wild mustard (44%), while inhibited redroot pigweed of the 71%. The highest concentration tested (C4) of cinnamon and lavender oils have controlled significantly all weeds. Ryegrass was inhibited for the 52% by the cinnamon and 51% for lavender, wild mustard for the 79% of cinnamon and 58% of lavender, while redroot pigweed reached the lethal dose with cinnamon oil and the 85% with lavender. Peppermint instead showed higher inhibition ability only for redroot pigweed (82%),

1 while for wild mustard (32%) and ryegrass (53%) the inhibition were lower than the C3
2 concentration.

3 The regression analysis between oil concentrations and seed germination shows as
4 general trend that increasing concentration of essential oil brings about increasing
5 inhibitory effects on weed seed germination till reaching a lethal dose (Fig. 4). It is
6 possible to see how for wild mustard and redroot pigweed the cinnamon oil had the
7 stronger inhibition effect, as shown by the regression coefficient values, while for
8 ryegrass was the peppermint oil that showed a stronger tendency of inhibition effect.

10 **Conclusion**

11 This research shows that there is potential to control weed germination using natural
12 compounds. Cinnamon is the oil with the stronger inhibition effect on the seed
13 germination of redroot pigweed and wild mustard. The inhibition of redroot pigweed
14 and wild mustard seedling emergence may have practical meaning because these
15 species are economically important weeds and have developed a resistance in
16 herbicides, even if with different modes of action (Owen, 2001). Peppermint oil has
17 been the more effective in inhibiting ryegrass seed germination. The identification of
18 this oil against a peculiar weed could be important in view of bio-herbicides to be used
19 with selectivity proprieties. Even the rate of the bio-herbicide concentration is an
20 important feature. It was found that the most effective dose tested (C4, Fig. 1 – 2 – 3) is
21 equal to 2.7 liters per hectare of pure cinnamon, peppermint and lavender oil,
22 respectively. These concentrations are comparable with recommended application rates
23 for many registered herbicides. So far, the results obtained make feasible to suggest an
24 application of the essential oil as bio-herbicide in controlled environment such as

horticulture as in green houses. Persistence of essential oils should be improved, these natural compounds being highly volatile and so less lasting in the environment. On the other side, for the same reason they have short half time are less harmful to the environment (Duke *et al.*, 1999). Further field research is necessary to develop an appropriate technology of essential oil application for inhibiting weed seed germination.

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Figure 1. Effect of the essential oils on the seed germination of ryegrass. In each graph the bars indicate LSD ($P \leq 0.05$) for the essential oil concentrations per day. C0, C1, C2, C3, C4 are 0 – 5.4 – 21.6 – 86.4 and 345.6 mg l^{-1} of essential oil, respectively.

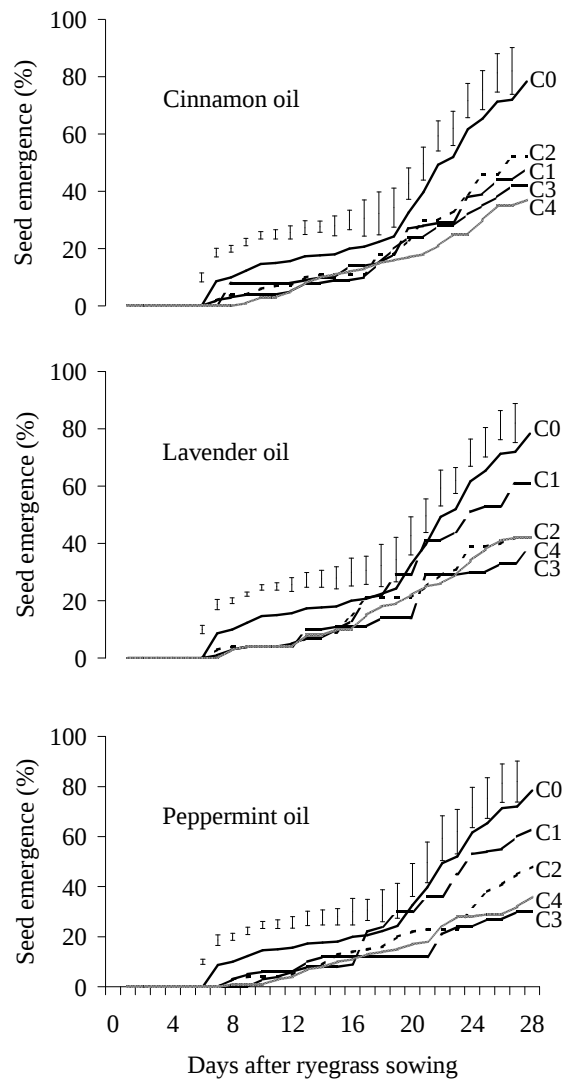


Figure 2. Effect of the essential oils on the seed germination of wild mustard. In each graph the bars indicate LSD ($P \leq 0.05$) for the essential oil concentrations per day. C0, C1, C2, C3, C4 are 0 – 5.4 – 21.6 – 86.4 and 345.6 mg l⁻¹ of essential oil, respectively.

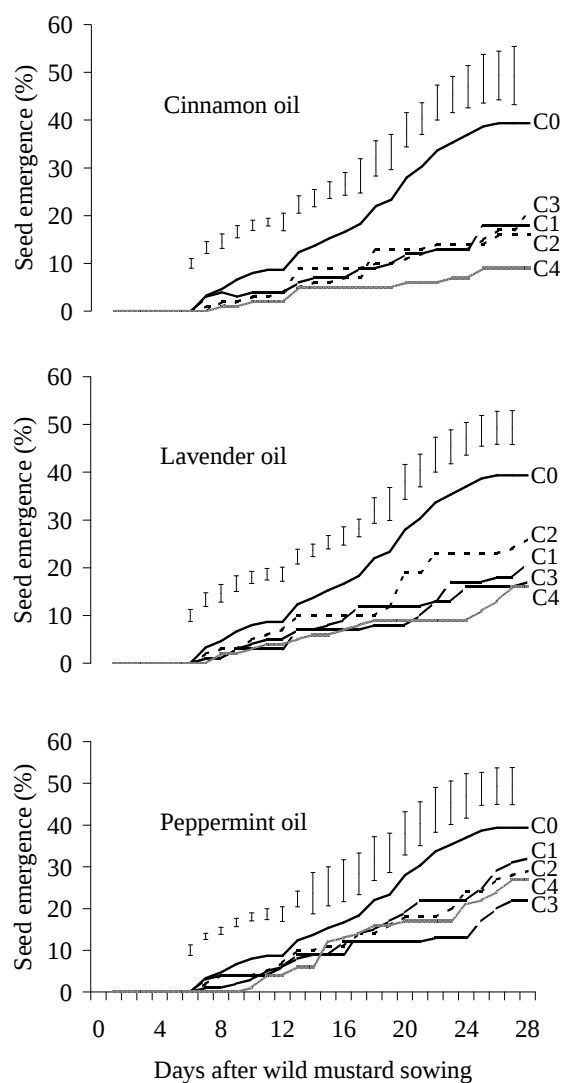


Figure 3. Effect of the essential oils on the seed germination of redroot pigweed. In each graph the bars indicate LSD ($P \leq 0.05$) for the essential oil concentrations per day. C0, C1, C2, C3, C4 are 0 – 5.4 – 21.6 – 86.4 and 345.6 mg l⁻¹ of essential oil, respectively.

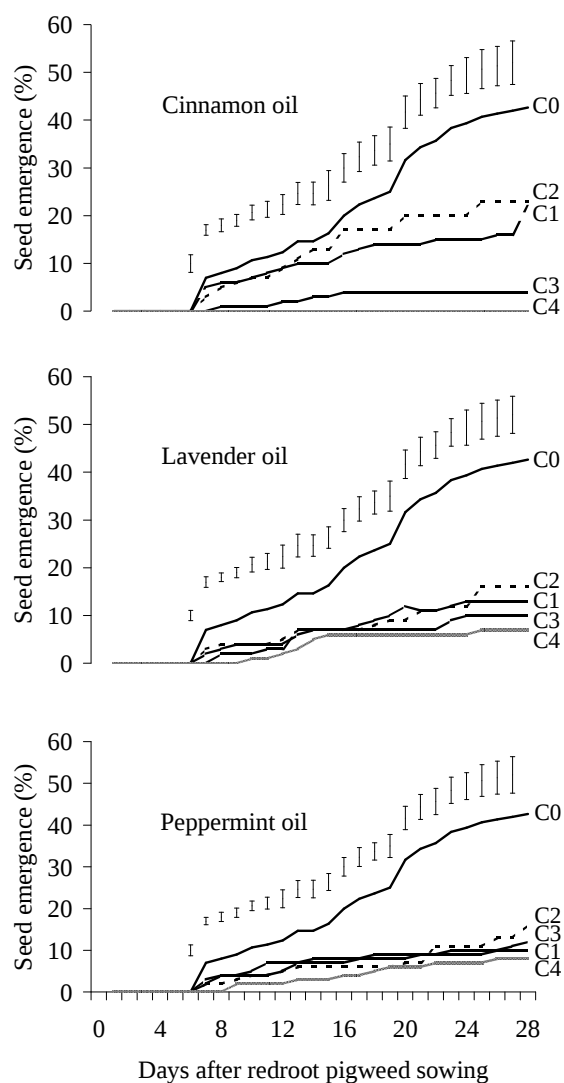


Figure 4. Regression analysis between seed germination and essential oils concentration. *, **, *** = significant at $P \leq 0.05$, $P \leq 0.01$, $P \leq 0.001$, respectively; ns = not significant.

