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Phytotoxicity of Citronellol against Two Weedy Species

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A B S T R A C T

A study was undertaken to assess the phytotoxic/ allelopathic potential of citonellol, a volatile monoterpene found in *Eucalyptus citriodora, E. globulus, Ocimum basilicum, Zingiber officinale, Coriandrum sativum, Citrus limon* and several other aromatic plants, against two weedy species *viz. Cassia occidentalis* and *Parthenium hysterophorus*. Citonellol was found to appreciably inhibit the germination of both the weedy species even at very low concentrations. However, the effect was more pronounced on *P. hysterophorus* than on *C. occidentalis.* Likewise, the seedling growth of both the test weedy species in terms of radicle length, seedling length and seedling dry weight was appreciably reduced in response to citronellol. Not only the growth, even the content of total chlorophyll and cellular respiration in both the test weeds was reduced quite significantly, thereby indicating that citronellol has a negative effect on the photosynthetic efficiency and the energy metabolism of the weed species. Based on the study, it is concluded that citronellol possesses weed-suppressing ability and can be used for future weed management programmes either directly or by serving as a lead molecule.

Introduction

Weeds, the plants that interfere with the activities and welfare of man and are an essential component of agroecosystems, lead to enormous crop losses the world over every year. As per an estimate, weeds cause an economic loss of about 100 billion US dollars worldwide (Appley and Muller, 2000).

Over the past few decades, indiscriminate use of synthetic herbicides though has undoubtedly enhanced the much needed crop production, yet have led to a number of toxicological, ecological, environmental and health problems (Macias *et al*., 2001). Therefore, efforts are being made the world over to search for safer and environmentally benign chemicals that are easily bio-degradable and are safe to human health. In this direction, biologically active natural products such as botanicals and allelopathic chemicals, being environment friendly and having different modes of action, are fast being tested for weed management (Kohli *et al.*, 1998; Dayan *et al*., 2000). They also play important roles in plant-plant

interactions, defence against herbivory, feeding attraction or repellence, pollinator attraction etc. (Vokou, 1999).

Among various classes of natural plant products, volatile monoterpenes have been shown to be promising with potential weed suppressing ability (Kohli *et al*., 1998; Singh *et al*., 2002). These are commonly found as components of essential oils in a number of aromatic plants, e.g. *Ocimum* spp., *Citrus* spp., *Corindrum* spp., *Eucalyptus* spp. and *Artemisia* spp. Besides, they also exhibit appreciable phytotoxicity towards a number of plants e.g. volatile terpenes of *Salvia leucophylla* are reported to be most effective in inhibiting the growth of grasses (Muller *et al*., 1964); *Eucalyptus* volatile terpenes reduce growth of a number of plants (Kohli and Singh, 1991); 1,4- and 1,8-cineoles reduce the growth of weeds (Romagni *et al*., 2000). Citronellol is one such volatile monoterpene, which is a major component of essential oils from a number of aromatic plants including *Eucalyptus* spp. and is biologically very active.

The present investigation was undertaken to explore the phytotoxic effect of citronellol against two weedy species *viz. Parthenium hysterophorus* and *Cassia occidentalis* with a view to explore its herbicidal potential against a wide range of weeds.

Materials and Methods

Collection of Material

Seeds of Coffee weed (*Cassia occidentalis* L.) and Congress Grass (*Parthenium hysterophorus* L.) were collected locally from wildly growing stands in the campus of Panjab University, Chandigarh. Citronellol was purchased from Lancaster, UK. The seeds were surface sterilized.

Bioassay Studies

Seeds of both the weed species were divided into 9 groups of 50 each and dipped in distilled water for 16 h for imbibition prior to germination trials. These were then equidistantly placed in 6" diameter Petri dishes lined with two layers of moistened Whatman no. 1 filter paper. The filter paper was treated with 0.1, 0.5, 0.7, 1, 2 and 5 µl of citronellol per Petri dish. After the addition of the volatile monoterpenes, the Petri dishes were sealed. A similar set-up but without the treatment of volatile monoterpenes served as control. For each treatment, 5 replicates were maintained. The entire set up was kept in an environmentally controlled seed germinating chamber at 25 ± 2 °C and 75 ± 2 % relative humidity with a photoperiod of 16/8 day/night. After a week, the number of seeds that germinated was counted, radicle length, seedling length and seedling dry weight were measured and the total chlorophyll content and percent respiratory activity were determined.

Estimations

Chlorophyll was extracted from 25 mg of tissue in 4 ml of Dimethyl sulphoxide (DMSO) following Hiscox and Israelstam (1979). Its concentration was determined spectrophotometrically (Arnon, 1949) and the amount was expressed in terms of dry weight as suggested by Rani and Kohli (1991). Respiratory values were determined indirectly using 2,3,5-triphenyl tetrazolium chloride as per the method of Steponkus and Lanphear (1967).

Statistical Analysis

The data of percent germination, radicle length, seedling length, seedling dry weight, chlorophyll content and respiratory activity

was analyzed by one-way ANOVA followed by Duncan's multiple range test.

Results and Discussion

It is very clear from the results that in response to different concentrations of citronellol, germination of both the weedy species were considerably reduced (Table 1). Reduction in germination was more in case of *P. hysterophorus* compared to *C. occidentalis*. A complete inhibition of germination of *P. hysterophorus* was observed at a concentration as low as 1 µl whereas in case of *C. occidentalis* it was seen at 5 µl concentration. Similarly, the radicle length of both the test weeds was significantly reduced in response to the monoterpene and the effect was more drastic in case of *P. hysterophorus* (Table 1).

Table.1 Effect of Citronellol on the Percent Germination and Radicle Length (cm) of *P. hysterophorus* and C. *occidentalis*

Concentration (µl)	Percent Germination		Radicle Length (cm)	
	P. hysterophorus	*C. occidentalis*	*P. hysterophorus*	*C. occidentalis*
0	**100** ± 3.46^{a}	**100** ± 0^{a}	***1.89*** *± 0.55*^{a}	**3.7** ± 0.18^{a}
0.1	**63.41** ± 2.0^{b}	**100** ± 0^{a}	**1.31** ± 0.44^{b}	**2.88** ± 0.53^{b}
0.5	**50.40** ± 1.15$_{c}$	**100** ± 0^{a}	**0.88** ± 0.19^{c}	**2.65** ± 0.35^{bc}
0.7	**43.90** ± 4.0^{d}	**86.67** ± 3.78^{b}	**0.86** ± 0.32^{c}	**2.55** ± 0.21^{c}
1	**0**	**60** ± 2^{c}	**-**	**2.5** ± 0.1^{c}
2	**0**	**56.67** ± 1.78^{c}	**-**	**2.25** ± 0.38^{d}
5	**0**	**-**	**-**	**-**

Different superscripts in a column represent significant difference at P<0.05

Table.2 Effect of Citronellol on the Seedling Length and Seedling Dry Weight of P. *hysterophorus* and C. *occidentalis*

Concentration (µl)	Seedling Length (cm)		Seedling Dry Weight (mg)	
	P. hysterophorus	*C. occidentalis*	*P. hysterophorus*	*C. occidentalis*
0	**2.74** ± 0.34^{a}	**10.57** ± 0.87^{a}	***0.28*** *± 0.05*^{a}	**11.3** ± 0.04^{a}
0.1	**2.39** ± 0.51^{b}	**7.58** ± 0.49^{b}	**0.18** ± 0.02^{b}	**10.48** ± 0.28^{b}
0.5	**1.88** ± 0.73^{c}	**7.57** ± 0.26^{b}	**0.17** ± 0.02^{b}	**9.66** ± 0.06^{c}
0.7	**1.24** ± 0.12^{d}	**7.18** ± 0.25^{c}	**0.15** ± 0.04^{b}	**9.28** ± 0.22^{c}
1	**-**	**7.08** ± 0.33^{c}	**-**	**8.75** ± 0.42^{d}
2	**-**	**6.27** ± 0.75^{d}	**-**	**7.72** ± 0.09^{e}
5	**-**	**-**	**-**	**-**

Different superscripts in a column represent significant difference at P<0.05

Table.3 Effect of Citronellol on the Total Chlorophyll Content and Percent Cellular Respiration of *P. hysterophorus* and C. *occidentalis*

Concentration (µl)	Total Chlorophyll Content (µg/mg)		Percent Cellular Respiration	
	P. hysterophorus	*C. occidentalis*	*P. hysterophorus*	*C. occidentalis*
0	**10.8** ± 0.12[a]	**8.72** ± 0.04[a]	***100*** ± *4.23*[a]	**100** ± 0.6[a]
0.1	**7.43** ± 0.05[b]	**6.3** ± 0.18[b]	**47.67** ± 8.55[b]	**92.95** ± 1.63[b]
0.5	**4.31** ± 0.1[c]	**5.18** ± 0.08[c]	**32.25** ± 4.22[c]	**43.78** ± 0.33[c]
0.7	**4.30** ± 0.06[c]	**4.17** ± 0.06[d]	**19.71** ± 4.12[d]	**35.84** ± 2.26[d]
1	-	**3.44** ± 0.06[e]	-	**31.30** ± 0.27[d]
2	-	**2.39** ± 0.07[f]	-	**20.84** ± 0.13[e]
5	-	-	-	-

Different superscripts in a column represent significant difference at P<0.05

Further, seedling length and seedling dry weight of both the test weeds were significantly reduced compared to control. For these parameters also, the effect was much more pronounced on *P. hysterophorus* compared to *C. occidentalis* (Table 2). Disruption of mitotic activity in the germinating seeds could be responsible for the observed inhibition of germination and growth of the weedy species. References available in literature can strengthen this fact (Romagni *et al*., 2000). Several reasons have been put forward to find out the factors that disrupt mitosis such as disruption of microtubule organization or alternation of cell wall biosynthesis (Lehnen and Vaughn, 1992).

The content of chlorophyll extracted in DMSO was significantly less in citronellol-treated samples compared to control. More reduction in chlorophyll content was observed in *P. hysterophorus* as compared to *C. occidentalis* (Table 3). The decrease in chlorophyll suggests the diminishing photosynthesis efficiency in response to the test monoterpene. The mechanism behind the decrease in chlorophyll content in the target weed i.e. whether it is due to its decreased synthesis or enhanced degradation could not be ascertained. However, available references from literature indicate reduced levels of chlorophyll pigment in response to allelopathy / allelochemicals (Romagni *et al*., 2000; Singh *et al*., 2002).

The present study also reveals a considerable and appreciable reduction in cellular respiration in both the weed species when treated with citronellol (Table 3).

It is concluded from the present study that citronellol has a potential to reduce the germination, growth and development of weed species and thus could be very useful for future weed management programmes either directly or by serving as a the lead molecule.

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