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ASSESSMENT OF ALLELOPATHIC POTENTIAL OF *ARTEMISIA SCOPARIA* AGAINST SOME PLANTS

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ABSTRACT
A study was conducted to explore allelopathic potential of volatile oil from *Artemisia scoparia* leaves against *Triticum aestivum*, *Zea mays*, *Amaranthus viridis, Chenopodium murale* and *Bidens pilosa*. Under laboratory bioassay, seed germination, seedling length, seedling dry weight, chlorophyll content and respiratory activity of different test plants were measured. Different concentrations (0.5, 1.0. 2.5 and 5.0 μL/Petri dish) of *Artemisia* oil inhibited seed germination of all the test plants. Besides early growth, the chlorophyll content and cellular respiration were also found to be severely affected upon *Artemisia* oil treatment. In general, the inhibitory effect was greater on weeds than on crops. Among the test plants, *A. viridis* was observed to be the most sensitive. The study concludes that *Artemisia* oil possesses stron phytototxicity against weeds and hence could be used as a bioherbicide.

INTRODUCTION

Allelopathy is a phenomenon involved in plant-plant interaction through release of allelochemicals from different parts of plant (Weston and Duke, 2003). Allelochemical interactions between plants play an important role in plant dominance, succession, and determining the structure and composition of plant communities, climax of vegetation and crop productivity (Chou, 1999; Batish *et al*., 2004). Among various allelochemicals, volatile essential oils from aromatic plants and their constituent monoterpenes constitute one of the major classes of allelochemicals. Recently, these have received considerable attention due to their weed suppressing potential besides other multiple ecological roles (Batish *et al*., 2008). Unlike other mechanisms of allelopathy, studies on allelopathic effects of volatiles produced from *Artemisia scoparia* in plant-plant interactions have been less investigated.

Artemisia scoparia (redstem wormwood; family Asteraceae), is a faintly scented annual herb known for its essential oil. The plant is now widespread found in central Europe and south west Asia including China, Japan and India (western Himalayas from Kashmir to Lahul up to an elevation of 1500–2100 m and upper gangatic plains; Kapoor *et al*., 2004; Mirjalili *et al*., 2007). The plant grows very fast and forms its monocultures in cultivated as well as uncultivated lands. The plant yields oil from almost every part that have long been recognized for a wide spectrum of biological activities such as antibacterial (Yeung, 1985), hepatoprotective (Yeung, 1985; Perry, 1980) and antioxidant (Singh *et al*., 2009). Though a number of studies have been conducted regarding its medicinal value and composition of oil from aerial parts (Basher *et al*., 1997; Kapoor *et al*., 2004; Safaei-Ghomi *et al*., 2005), very little has been done to explore the allelopathic potential of its oil. Therefore, the present study aims to explore the allelopathic potential of volatile oil from leaves of *A. scoparia* against some crops and weeds with a view of using it as a bioherbicide for weed management.

MATERIALS AND METHODS

Extraction of oil

The oil was extracted using Clevenger's apparatus as per Singh *et al*. (2009). The freshly collected leaves (250 g) of *Artemisia scoparia* Waldst. and Kit. growing in wastelands of Chandigarh were chopped, mixed with 1L distilled water in a 2L round bottom flask and fitted with condenser. The mixture was boiled for 3 h and oil collected was dried under sodium sulphate and stored at 4ºC for further identification and bioassay. The oil so obtained was clear yellow oil in color with a yield of 0.17% (v/w) on fresh weight basis.

Collection of seeds of test plants

The crops and weeds were used as test species. Seeds of crops such as *Triticum aestivum* and *Zea mays*, were procured from Punjab Agricultural University, Ludhiana (Punjab) whereas those of weeds namely *Amaranthus viridis, Chenopodium murale and Bidens pilosa* were collected locally from vacant areas surrounding Panjab University campus. Prior to germination test, seeds of all test plants were surface sterilized with 0.1% sodium hypochlorite for 2 minute, washed with distilled water and stored for further use.

Germination and growth studies

Bioassay for the allelopathic potential of essential oil was carried out under laboratory conditions. Seeds of all test plants were dipped in sufficient quantity of water for 16–18 hr for imbibition. The imbibed seeds were germinated in Petri dishes

(15 cm diameter) lined with filter paper (Whatman No.1) moistened with distilled water. Different amounts (0.5, 1.0, 2.5 and 5.0 μL /Petri dish) of *Artemisia* oil were loaded on the inner side of lid of Petri dish and then sealed immediately with parafilm. Petri dish without oil treatment served as control. For each concentration, five replicates were maintained. All the Petri dishes were kept in a growth chamber maintained at 16/8 light/dark period, 25 ± 2ºC (for summer plants) and 20 ± 2ºC (for winter plants) temperature and a relative humidity of nearly 80% and a photoperiod of 150 μmole m^{-2} s^{-1}. After 7 days, the number of seeds that germinated was counted, the length of emerged seedlings was measured and their dry weights were taken after oven drying seedlings at 60ºC for 48 hr.

Determination of chlorophyll content

The chlorophyll content was measured using dimethyl sulphoxide as per method of Hiscox and Israelstam (1979). Its concentration was determined spectrophotometrically using the equation of Arnon (1949) and expressed on dry weight basis.

Determination of cellular respiration

The cellular respiration was determined indirectly using 2, 3, 5-triphenyl tetrazolium chloride following the method of Steponkus and Lanphear (1967) as per Batish *et al*., (2008). The absorbance was read at 530 nm and the values were expressed with respect to control.

RESULTS AND DISCUSSION

Effect on early growth

All the seeds of test plants germinated in control registering 100% germination. However, it reduced upon treatment with different concentrations of *Artemisia* oil in all test plants (Table 1). In general, more inhibition was observed in weeds compared to crops. Maximum inhibition (~88%) was observed in *A. viridis* whereas the minimum (~22%) was observed in *T. aestivum* (Table 1). Like germination, seedling length of test plants was also reduced upon treatment with *Artemisia* oil. In control, the seedling length of *T. aestivum*, *Z. mays*, *B. pilosa*, *C. murale* and *A. viridis* were 19.1 ± 2.3, 15.6 ± 1.5, 4.3 ± 0.9, 5.2 ± 0.8 and 4.0 ± 0.7 cm, respectively. The seedling length decreased in response to different concentrations of *Artemisia* oil. With treatment of 5.0 μL *Artemisia* oil, the seedling length decreased by ~26, 29, 49, 52 and 60% in *T. aestivum*, *Z. mays*, *B. pilosa*, *C. murale* and *A. viridis*, respectively, over control (Table 2). Further, test plants exhibited a similar trend of reduction in seedling dry weight upon treatment with different *Artemisia* oil though the magnitude of reduction was lesser compared to seedling length. With the treatment of lower concentration of *Artemisia* oil, the reduction in seedling dry weight of test crops was statistically insignificant whereas it was significant in weeds. At higher concentrations, all the test plants exhibited significant (~23–41%) reduction in dry weight (Table 3). The results clearly show that *Artemisia* oil exhibits allelopathic properties as indicated by reduced germination and early growth of test plants. In general, the phytotoxic effect was severe in case of weeds compared to crops. The results obtained in present study are parallel to earlier reports which have documented that volatile oils from aromatic plants and their constituent monoterpenes are potent inhibitors of germination and growth (Kong *et al*., 1999; Dudai *et al*., 2000; Mao *et al*., 2004; Ibrahim *et al*., 2004; Azirak and Karaman, 2008; Bakkali *et al*., 2008; Batish *et al*., 2008; Singh *et al*., 2009). Many workers have demonstrated the mechanism of action of volatile oils. Volatile oils and their constituent monoterpenes impair cell division in growing cells (Vokou *et al*., 1993; Duke *et al*., 2000; Romagni *et al*., 2000; Singh *et al*., 2006) and bring about ultrastructural changes in root apical meristem of treated roots (Lorber and Muller, 1976) resulting in reduced growth. The rapid loss of ions from cellular membrane upon oil treatment may also be one of the causes of allelopathic effects of volatile oil and its monoterpenes (Singh *et al*., 2005, 2006; Batish *et al*., 2007).

Effect on chlorophyll and respiration

In addition to germination and early seedling growth, a drastic decrease in chlorophyll content was also observed in the oil-treated seedlings. At lower concentration of *Artemisia* oil (0.5 μL), different test species exhibited ~8–23% reduction in chlorophyll. The chlorophyll content further declined with increasing concentrations of *Artemisia* oil. It was reduced by 33, 44, 69, 64 and 80% in *T. aestivum*, *Z. mays*, *B. pilosa*, *C. murale* and *A. viridis*, respectively, compared to control (Table 4). The observed decrease was statistically significant.

Furthermore, the cellular respiration of seedlings of test plants also declined upon treatment of *Artemisia* oil. In general, more

Table 1: Percent inhibition in germination of test plants in response to different concentrations of *Artemisia* oil.

Concentration(μL/Petri dish)	*T. aestivum*	*Z. mays*	*B. pilosa*	*C. murale*	*A. viridis*
0.5	2.6ns	0.5 ns	2.6 ns	6.5*	6.0*
1.0	10.4*	8.9*	20.5*	15.6*	17.5*
2.5	13.6*	14.7*	39.4*	49.6*	30.5*
5.0	21.5*	25.0*	58.5*	60.5*	87.6*

*indicates significant difference from control at $p < 0.05$ applying Dunnett's test; ns: non-significant.

Table 2: Percent inhibition in seedling length of test plants in response to different concentrations of *Artemisia* oil.

Concentration(μL/Petri dish)	*T. aestivum*	*Z. mays*	*B. pilosa*	*C. murale*	*A. viridis*
0.5	03.4 ns	01.6*	15.7*	11.1*	14.8*
1.0	10.6*	08.4*	30.3*	23.5*	28.9*
2.5	17.6*	15.6*	39.4*	40.5*	37.4*
5.0	25.6*	29.3*	49.4*	52.3*	60.2*

*indicates significant difference from control at $p < 0.05$ applying Dunnett's test; ns: non-significant.

Table 3: Percent inhibition in seedling dry weight (mg) of test plants in response to different concentrations of *Artemisia* oil.

Concentration(μL/Petri dish)	*T. aestivum*	*Z. mays*	*B. pilosa*	*C. murale*	*A. viridis*
0.5	02.2 ns	03.4 ns	12.3*	7.4*	5.6*
1.0	07.5*	09.2*	19.6*	18.0*	17.8*
2.5	14.6*	12.7*	26.7*	27.1*	22.1*
5.0	22.5*	20.5*	37.2*	41.1*	40.9*

*indicates significant difference from control at $p < 0.05$ applying Dunnett's test; ns: non-significant.

Table 4: Effect of *Artemisia* oil on chlorophyll content (μg/mg dry weight) of different test plants.

Concentration(μL/Petri dish)	*T. aestivum*	*Z. mays*	*B. pilosa*	*C. murale*	*A. viridis*
0	5.1	5.8	12.6	11.7	5.9
0.5	4.7	5.1*	10.4*	09.0*	4.8*
1.0	4.3*	4.5*	08.6*	07.9*	3.7*
2.5	4.0*	3.9*	05.1*	05.7*	3.0*
5.0	3.4*	3.3*	04.0*	04.2*	1.2*

*indicates significant difference from control at $p < 0.05$ applying Dunnett's test; ns: non-significant.

Table 5: Effect of *Artemisia* oil on cellular respiration (%) of different test weeds.

Concentration(μL/Petri dish)	*T. aestivum*	*Z. mays*	*B. pilosa*	*C. murale*	*A. viridis*
0	100	100	100	100	100
0.5	97.4	94.2*	92.3	95.4*	91.3*
1.0	88.4*	85.1*	82.3*	82.3*	76.4*
2.5	79.3*	80.0*	60.3*	70.3*	66.1*
5.0	73.4*	76.5*	50.4*	56.5*	41.5*

*indicates significant difference from control at $p < 0.05$ applying Dunnett's test; ns: non-significant.

decrease was observed in weeds compared to crops. Minimum respiration was noticed in *A. viridis* followed by *C. murale* whereas *T. aestivum* was least affected by different concentration of *Artemisia* oil (Table 5). Further, in response to *Artemisia* oil, the chlorophyll content and cellular respiration of the seedlings were drastically affected. This may be due to interference of volatile oil in the processes of photosynthesis and respiration. Though, the exact mechanism for reduction of chlorophyll content in treated plants is still unknown yet decrease in chlorophyll synthesis or increase in chlorophyll degradation or even both could be one of the reasons of reduction in chlorophyll content (Singh *et al*., 2005; Batish *et al*., 2007). Moradshahi *et al*. (2003) reported volatile oil of *Eucalyptus camaldulensis* reduce chlorophyll content by adversely affecting Hill reaction in *Spinacea oleracea*. Drastic decrease in cellular respiration upon exposure to volatile oil shows impairment in energy metabolism. These observations are in agreement with earlier reports which show the allelopathic effects of volatile oils (Abrahim *et al*., 2000; Singh *et al*., 2005, 2009). From the study, it is clear that *Artemisia* oil exerts allelopathic effects on different plants and the effect is severe on weeds than crops and thus exhibit species specificity which can be used for weed management. However, further studies are required in this regarding.

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