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ALLELOPATIC EFFECT OF MEDICINAL PLANTS ON EMERGENCE UNIFORMITY AND SEEDLING VIGOR OF WEED PLANTS CASE STUDY: FENNEL, VELVETLEAF, BINDWEED

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ABSTRACT

In sustainable agricultural strategies there is a world-wide effort to reduce the amount of herbicides used in production by introducing modern biological and ecological methods. Essential oils were reported as inhibitors of seed germination and plant growth. In order to evaluating emergence and stand establishment of weeds as affected by allelopatic effect of fennel extract an experiment was conducted at the Research Station of Islamic Azad University of Tabriz, Iran during 2013. The velvetleaf (*Abutilon theophrastii*) and field bindweed (*Convolvulus arvensis*) seeds were obtained from weed institute of Iran, Tehran. Studied treatments were essence concentrations as 100, 200, 300 and 400 ppm. LSD test was used to compare the differences among treatment means. Both weeds studied responded positively and similarly to studied treatments. When pots irrigated with lower dose of essence, time to start emergence, time taken to 50 % of emergence of seedling and mean emergence time were statistically same as control. All the treatments also decreased the coefficient of uniformity of emergence compared with non-treated seeds; however, minimum coefficient of uniformity of emergence was recorded from 300 and 400 ppm essence concentrations. Maximum seedling dry weight (0.49 g.plant^{-1}) was noticed in control (0.96 g.plant^{-1}) followed by 100 ppm treatment (0.90 g.plant^{-1}), and the lowest from treatments of 200, 300 and 400 ppm treatments. The data shows that seedling vigor index can be decreased by essential oil concentrations with the same trend of seedling dry weight. In the present study a further reduction in essential oil concentration from 200 ppm could restrict seedling vigor index significantly. As a conclusion, higher essence concentration of fennel essential oil could be potentially effective in controlling of the weeds studied.

Keywords: coefficient of uniformity, seedling vigor index, stands establishment, sustainable agriculture.

INTRODUCTION

Fennel (*Foeniculum vulgare* Mill.) is one of the medicinal plants of the Apiaceae family; due to its estrogenic activities and usage as a carminative and antimicrobial; it has also been used to increase the production of milk in humans and animals [1]. Allelopathy is a kind of stress. It may be decrease leaf area and leaf chlorophyll content for reducing efficiency of photosynthesis of plants [2]. An allelopathic plant can potentially be used to control weeds. In a rotational sequence, when an allelopathic plant is left as a residue or mulch, especially in minimum-tillage systems could control subsequent weeds growth. Also, allelopathy is characterised by a reduction in plant emergence or growth, and reducing their performance in the association [3].

Many seed priming treatments have been used to reduce germination and growth in plants [4]. Time of weeds plant emergence and establishment in crop fields is one of the major challenges in crop production and its importance is recognized by farmers as well as researchers [5]. Essential oils from medicinal plants were reported as inhibitors of seed germination and plant growth [6]. Evidence for allelopathic interactions caused by aromatic plants containing volatile allele-chemicals have been described by Muller *et al*. [7] and Rice [8]. Fennel (*Foeniculum vulgare* L.) is an aromatic evergreen tree, native to the Mediterranean regions. The most abundant essential oil found in laurel is cineole, also called eucalyptol [9].

Velvetleaf (*Abutilon theophrastii*) is a large genus of *Malvaceae* family. It is distributed throughout Asia [10]. Field bindweed (*Convolvulus arvensis*) is a species of *Convolvulaceae* family, native to Europe and Asia [11]. The both plants are as troublesome weeds in crop plant fields of Iran. Research of Hemada and EL. Darier [12] resulted that germination percentage attended a value of about 100% at control level for both the two target thyme species and the two test species. Seeds of *Lepidium sativum* treated with maximum essence concentration of *Thymus capitatus* and *T. vulgaris*, germinated 33% and 60%, respectively, while, about 65 and 80%, respectively, for *Raphanus sativus*. It is important to mention that *R. sativus* seeds were highly resistant to essence as compared with *L. sativum*, which is the most sensitive.

In an experiment conducted by Challa and Ravindra [13], *Portulaca* leaf leachates reduced the root growth of onion. Also, leaf leachates of *Portulaca oleracea* and *Cyperus rotundus* lead to 63% and 50% reduction of root growth in radish. In several reports, stem height, root and shoot dry weights of squash (*Cucurbita pepo*) and pepper (*Capsicum annum*) were reduced by root extracts of medicinal plants [14]. The essential oils extracted from above-ground parts of *Salvia hierosolymitana* and *S. multicaulis* have shown phytotoxic activity against seed germination and initial radical elongation of radish. In Rowshan and Karimi [15] experiment the plumule length, plumule fresh weight and dry weight of seedlings were reduced significantly in

response to the *S. macrosiphon* extracts, and the leaves were the most allelopathic. *S. macrosiphon* extracts at concentrations of 100% decreased corn radicle and plumule lengths, radicle and plumule fresh weights, radicle and plumule dry weights 76, 52, 65, 45, 68 and 40% with root extract and 99, 100, 100, 100, 100 and 100% with leaf extract, respectively. Azizi and Fuji [16] concluded that a diluted extract of John's wort (*Hypericum perforatum*) and sage (*Salvia officinalis*) had a significant inhibitory effect on seed germination rate of *Amaranthus retroflexus*, but non-effective for *Portulaca oleracea*. *Eugenia uniflora* appears to be growth stimulatory, whereas, *P. guineense* is growth inhibitory at concentrations more than 400 ppm [17]. Eucalyptus essential oil had a strong inhibitory effect on the germination of some weed species. Dudai *et al*. [18] have previously reported on the effect of monoterpenes from a number of aromatic plants on wheat seed germination and have also shown that the seeds exposed to defined monoterpenes, are able to metabolize them. There is a little information about influence of allelopatic effect of fennel extract on weed growth. The main object of this study was evaluating emergence and stand establishment of weeds as affected by allelopatic effect of fennel extract.

MATERIALS AND METHODS

Site description

In order to study allelopatic effect of fennel extract to control of velvetleaf and field bindweed an experiment was conducted at the Research Station of Islamic Azad University of Tabriz, Iran during 2013.

Experimental design

The fennel (*Foeniculum vulgare*) essence used for this study were obtained from Pakan Bazr Institute, Iran with purity of 89%. The velvetleaf (*Abutilon theophrastii*) and field bindweed (*Convolvulus arvensis*) seeds were obtained from weed institute of Iran, Tehran. The pot experiment was laid out in a completely randomized design in green house condition with three replicates and pots size was 19×21 cm. Treatments used in this study were selected from previous experiment conducted by Omidbeigi [19]. Studied treatments were essence concentrations as 100, 200, 300 and 400 per part million. Pots receiving no treatment served as control. Twenty five weed seeds for each treatment were placed in pots containing farm soil under green house conditions (25±1 °C) for an emergence test. Samples were thoroughly moistened with essence solutions and he pots were covered with parafilm for prevention of essence evaporation.

Measurements

In green house condition number of emerged seeds was recorded daily according to the seedling evaluation handbook of the Association of Official Seed Analysis. Final emergence percentage (FEP) was calculated as the cumulative number of germinated seeds with normal radicles by using equation (1), as described by Larsen and Andreasen [20].

$$FEP = \Sigma n / N \times 100 \quad (1)$$

Where, n is the number of germinated seeds at each counting and N is total seeds in each treatment.

Time taken to 50 % of emergence of seedling (E_{50}) was calculated according to the following formula of Coobear *et al*. [21].

$$E_{50} = t_i + (N/2\text{-}n_i)(t_j\text{-}t_i)/n_j\text{-}n_i \quad (2)$$

Where N is the final number of emerged seeds, and n_i and n_j are the cumulative number of seeds emerged by adjacent counts at times t_i and t_j when $n_i<N/2<n_j$.

Mean emergence time (MET) was calculated according to the equation (3) [22]:

$$MET= \Sigma Dn/ \Sigma n \quad (3)$$

Where n is the number of seeds which emerged on day D, and D is the number of days counted from the beginning of emergence.

Coefficient of uniformity of emergence (CUE) was calculated using the formula of Bewley and Black [23]:

$$CUE= \Sigma n/ \Sigma[(t - t)\times n] \quad (4)$$

Where t is the time in days starting from day 0, the day of sowing, n is the number of seeds completing emergence on day t and t is equal to MET.

Seedling vigor index (SVI) was calculated according to Abdul-Baki and Anderson [24] by using equation (5).

$$SVI = SDW\times FEP \quad (5)$$

Where, SDW is seedling dry weight.

Statistical analysis

Data were statistically analysed using the software MSTAT-C. Analysis of variance was used to test the significance of variance sources, while LSD test (P=0.05) was used to compare the differences among treatment means.

RESULTS AND DISCUSSIONS

Seed priming techniques significantly affected seedling emergence and stand establishment of weeds (Table-1). Both weeds studied responded positively and similarly to studied treatments. All the essence concentrations studied reduced the time to start emergence, E_{50} and MET compared with control. Minimum time to start emergence, E_{50} and MET were recorded from 200, 300 and 400 per part million essence concentrations. When pots irrigated with lower dose of essence, time to start emergence, E_{50} and MET were statistically same as control (Table-2). Beneficial effect of seed priming with essential oils on seedling emergence is

consistent with the farmers' perceptions of its effects on some medicinal plants such as cumin (*Cuminum cyminum* L.) and marigold (*Calendula officinalis* L.) [25]. All the treatments also decreased the CUE compared with non-treated seeds; however, minimum CUE was recorded from 300 and 400 per part million essence concentrations (Table-2). A lot of works have recently been done on seeds vigor [21, 26] that reduce seed performance and lower and non-synchronized germination. The effect of essential oils studied treatments on FEP of weed seeds was significant (Table-2). The averaged FEP from 100 and 200 per part million essence concentrations was nearly 53.9 %, which was statistically same as control, but only 37.3 % from 300 and 400 ppm treatments (Table-2). Study of Hemada and EL. Darier [12] revealed that the effects of essential oils extracted from the shoots of *Thymus capitatus* and *T. vulgaris* upon germination percentage prevention of *Lepidium sativum* and *Raphanus sativus* were positive and significant. Higher concentrations of leaf extracts from *Lavadula officinalis* and *Rosmarinus officinalis* on inhibiting of seed germination and growth of *Solanum nigrum* and redroot pigweed were more effective [27]. In another experiment conducted by Rowshan and Karimi [15] highest significant inhibition effects on seed germination were obtained by 100% of *S. macrosiphon* leaf extract. *S. macrosiphon* extract treatments not only decreased germination but also decreased growth and dry matter in corn seedlings. Treatments with 5%, 10%, 25%, 50% and 100% extracts decreased dry weight of corn significantly. Decreased seedling dry weight was resulted by decreased seedling growth. The plumule length, plumule fresh weight and dry weight of seedlings were reduced significantly in response to the *S. macrosiphon* extracts. In Rowshan and Karimi [15] experiment *Salvia macrosiphon* extract concentrations of 5% to 100% decreased germination of corn seeds significantly, compared to control. Also, increasing of leaf and root extracts concentration from 5% to 100% inhibited germination from 27% to 96% and 20% to 75% in comparison with control.

Table-1. Mean squares for studied variables in weed plants under essential oil treatment.

SVI	SDW (g.plant^{-1})	FEP	CUE	MET (days)	E_{50} (days)	Time to start emergence (days)	df	SOV
0.658	0.025	54.038	5.058	2.010	2.058	1.023	1	Weed species (A)
1.251*	22.320*	100.265*	51.215**	4.564*	11.847*	23.259*	4	Medicinal plant extract (B)
0.979	12.733	60.555	20.888	3.547	7.598	9.562	4	A×B
0.400	5.001	27.111	10.456	1.264	3.333	6.326	20	Error
10.59	22.02	19.19	16.12	25.00	11.55	29.58	-	CV (%)

*, ** mean significant difference at 5% and 1% probability levels, respectively.

Table-2. Mean comparisons for studied variables in weed plants under essential oil treatment.

SVI	SDW (g.plant^{-1})	FEP	CUE	MET (days)	E_{50} (days)	Time to start emergence (days)	Essential oil concentrations (ppm)
47.46 b	0.96 b	49.44 b	0.88 b	11.0 b	8.0 b	5.8 b	Control
50.79 b	0.90 ab	56.43 b	0.93 b	12.8 b	8.5 b	5.3 b	100
33.41a	0.60 a	55.69 a	0.90 b	17.5 a	10.0 a	7.3 a	200
24.18 a	0.60 a	40.30 c	0.61 a	16.2 a	11.0 a	7.8 a	300
13.72 a	0.40 a	34.30 c	0.50 a	15.8 a	9.9 a	8.0 a	400
20.20	0.33	8.22	0.15	1.66	1.33	0.85	LSD (5%)

Means with the same letter in each column have not significantly difference at 5% probability level in LSD.

In the pot experiment maximum SDW (0.49 g.plant^{-1}) was noticed in control (0.96 g.plant^{-1}) followed by 100 ppm treatment (0.90 g.plant^{-1}), and the lowest from treatments of 200, 300 and 400 ppm treatments (Table-2). In Rowshan and Karimi [15] experiment seedling growth of *Zea mays* in check plots were significantly higher than *Salvia macrosiphon* extract treatments. SVI responded negatively and significantly to priming treatments as compared to that of non-priming. The data shows that SVI can be decreased by essential oil concentrations with the same trend of SDW as observed above. In the present study, a further reduction in essential oil concentration from 200 per part million could restrict SVI significantly. Producing non-vigorously seedlings was also registered for sweet pepper (*Capsicum annum* L.) due to seed priming [28]. Besides, SVI from seeds treated with 100 ppm essence concentration was found to be similar to that of control.

CONCLUSIONS

As a conclusion, higher essence concentration of fennel essential oil could be potentially effective in controlling of the weeds studied.

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