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Allelopathic effect of Lavandin (*Lavandula x intermedia Emeric ex Loisel. var. Super A*) Oil on Germination and Seedling Development of Some Weed and Field Crops

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Abstract
In the present study, allelopathic effects of lavandin (*Lavandula x intermedia* Emeric ex Loisel. cv Super A) oil on germination and seedling development of common amaranth (*Amaranthus retroflexus* L.), dock (*Rumex crispus* L.) and wild mustard (*Sinapis arvensis* L.) and crop plants [wheat (*Triticum aestivum* cv Gün 91), sunflower (*Helianthus annuus* cv. Sirena) and chickpea (*Cicer arietinum*)] were investigated. All parameters were significant ($p<0.01$). The highest lavandin oil applications (20 µl and 4.0 mg kg^{-1}) was decreased germination of dock (83.1% and 67.6%), wheat (70.0% and 85.0%) and chickpea (94.8% and 100.0%) respectively compared to control. However, germination rate of wheat, chickpea and dock seed in low doses of lavandin oil (3 µl and 0.5 mg kg^{-1}) was higher than the other species. The increased doses of essential oil in pot study negatively affected the root length of dock, common amaranth and sunflower. The stem length of common amaranth, wild mustard and wheat at 0.5 mg kg^{-1} dose was increased by 20.1%, 22.5% and 1.0%, respectively. As a result, it was determined that lavandin oil (3 µl and 0.5 kg ha^{-1}) at low doses significantly inhibited weed seed germination and was less damaging to crop plants seed germination.

Key Words: Allelopathy; germination; lavandin; seedling growth

Bazı Yabancı Ot ve Tarla Bitkileri Tohumlarının Çimlenmesi ve Fide Gelişimi Üzerine Lavanta (*Lavandula x intermedia Emeric ex Loisel. var. Super A*) Uçucu Yağının Allelopatik Etkisi

Özet
Araştırmada, bazı yabancı ot [horozibiği (*Amaranthus retroflexus* L.), labada (*Rumex crispus* L.) ve yabani hardal (*Sinapsis arvensis* L.)] ve kültür bitkilerinin [buğday (*Triticum aestivum* var. Gün 91), ayçiçeği (*Helianthus annuus* var. Sirena) ve nohut (*Cicer arietinum*, köy populasyonu)] tohumlarının çimlenmesi ve fide gelişimi üzerine lavanta (*Lavandula x intermedia* Emeric ex Loisel. var. Super A) uçucu yağının etkisinin belirlenmesi amaçlanmıştır. Petri ve saksı denemelerinde incelenen bütün özellikler istatistiksel olarak $p<0.01$ düzeyinde önemli bulunmuştur. Elde edilen sonuçlara göre; kontrol dozuna göre en yüksek uçucu yağ uygulamasında (20 µl ve 4.0 mg kg^{-1}) labadada (% 83.1 ve % 67.6), buğdayda (% 70.0 ve % 85.0) ve nohutta ise (% 94.8 ve % 100.0) oranında çimlenme olumsuz yönde etkilenmiştir. Ancak düşük dozlarda (3 µl ve 0.5 mg kg^{-1}) buğday, nohut ve labada tohumlarının çimlenme oranı diğer türlere göre daha az etkilenmiştir Saksı denemelerinde ise artan uçucu yağ dozu labada, horozibiği ve ayçiçeğinin kök uzunluğunu olumsuz etkilemiştir. Horozibiği, yabani hardal ve buğdayın saksı denemelerinde ise 0.5 mg kg^{-1} dozunda gövde uzunluklarında sırasıyla %20.1, %22.5 ve %1 oranında artış meydana gelmiştir. Sonuç olarak; lavanta uçucu yağının düşük dozlarda (3 µl ve 0.5 kg da^{-1}) yabancı otların çimlenmesini önemli oranda engellediği ve tarla bitkilerine ise daha az zarar verdiği belirlenmiştir.

Anahtar Kelimeler: Allelopati, çimlenme, lavanta, fide gelişimi

Introduction

There are large numbers of weeds in agricultural production areas. 7000 species in the world and 1800 species in Turkey have been identified as harmful weeds in agricultural areas and their damage is around 32% to our country (Aydın and Tursun, 2010). The herbicides comprise half of the pesticides used in the world. Drug users have been increased due to easier and quicker application to large areas and expensive the labour force in agriculture. However, the situation leads to an irreversible problem (Rice, 1984). One of the most important strategies against weeds is phytotoxic damage in the agricultural areas, which depends on preventing the enzyme activity, inhibiting germination and growth of plant compounds. So far, studies on extracts with herbicide effect were derived from secondary metabolites in plants have been demonstrated.

Monoterpenes has the major responsible for phytotoxic effect. Lavandula (*Lavandula hybrida* L.), oregano (*Origanum onites*), sage (*Salvia officinalis* L.), peppermint (*Mentha piperita*), rosemary (*Rosmarinus officinalis*) and fennel (*Foeniculum vulgare*) essential oil as well as many from medicinal and aromatic plants are obtained essential oil and monoterpenes are contained within the maximum of these essential oils. One of the alternative methods is to be used the allelopathic substances (secondary metabolites, allelochemicals) against weeds, pests and plant diseases. Awareness of the availability of these substances in biological control against weeds increased the importance of allelopathic effects in crop production practices (Rice, 1984). Allelopathy is defined as a limiting or enhancing effect as the development of plants of each other as a result of various chemical mechanisms (Türkmen and Turhan, 2006). Allelopathic plant products along with using of a wide field can be used instead of directly herbicide besides these are an important role in creating the basis for new synthetics herbicides.

The aim this research was to determine allelopathic effects of lavandin oil (*Lavandula x intermedia* Emeric ex Loisel. cv Super A) on germination and seedling development of common amaranth (*Amaranthus retroflexus* L.), dock (*Rumex crispus* L.) and wild mustard (*Sinapis arvensis* L.) and crop plants [wheat (*Triticum aestivum* cv Gün 91), sunflower (*Helianthus annuus* cv. Sirena) and chickpea (*Cicer arietinum*)].

Material and Method

This research was carried out Suleyman Demirel University, Faculty of Agriculture, and Department of Field Crops. In this study, seeds of weeds species such as common amaranth (*Amaranthus retroflexus* L.), dock (*Rumex crispus* L.) and wild mustard (*Sinapis arvensis* L.) and cultivated plant species such as wheat (*Triticum aestivum* cv. Gün 91), sunflower (*Helianthus annuus* cv. Sirena) and chickpea (*Cicer arietinum*, landraces)] were used as material. Also, lavandin (*Lavandula x intermedia* Emeric ex Loisel. var. Super A) essential oil was used to determine the allopathic effect. Weed seeds in maturation period were collected during the months of July to September 2009 from the crop cultivation areas.

In petri experiments; 0 (control), 3, 6, 10 and 20 µl doses, in pot experiment; 0, 0.5, 1.0, 2.0, and 4.0 mg kg^{-1} doses of lavandin oil is applied on germination of weed and crop plants seeds (Azirak and Karaman, 2008; Gülsoyve ark., 2008). Whatman filter was placed into petri dishes and lavandin oil was

uniformly defused inside petri dishes. Twenty five (25) seeds were put into and, 10.0 ml distilled water was added to each petri dishes. Field soil with the texture clayed-calcareous, alkaline (pH 8.1), Cation Exchange Capacity 36.0% and total salt composition 0.025%, rich in lime (75.4 K_2O da^{-1}) and in point of poor in organic material (1.34%), insufficient in available soil moisture was used in pot experiment. Only distilled water was used for control doses.

Seeds within petri dish and pots were allowed to germinate during 15 days in room condition (25˚C). At the end of this period, germination rate, root and stem length and dry matter rate were investigated. The components of the lavandin oil were analyzed by Gas Chromatography Mass Spectrometry (GCMS). GC-MS analysis was performed on QP5050 GCMS equipped with a Quadrapole detector. GCMS analysis was carried out as follows: capillary column, CPWax 52 CB (50 m x 0.32 mm i.d, film thickness, 0.25 µm), oven temperature was kept at 60 ^oC for 10 min and programmed to 220 ^oC at a rate of 10 $^oCmin^{-1}$, and then kept constant at 220 ^oC for 10 min., total run time 60 min., injector temperature, 240 ^oC; Detector (70 eV) temperature, 250^oC; Flow rate for helium, 20 mL min^{-1}. Identification of constituents was carried out with the help of retention times of standard substances by composition of mass spectra with the data given in the NIST library (Stein, 1990) and our created library.

This experiment was designed in completely randomized plot design with 3 replications. Germination times in experiments were determined according to ISTA (2009) rules. All characters means were objected to analysis of variance (ANOVA) using SAS (1998) program and differences among treatments were tested with Duncan Multiple Test. Before the analyses germination rate was applied to arcsine transformation.

Results and Discussion

According to GC-MS analysis, 18 components in lavandin oil were determined. It was reported that more than 80 other components in lavandin oil by Harborne and Williams, 2002. The major two components in lavandin oil were linalool (43.65 %) and linalyl acetate (24.65 %). The other composition rate was 31.77% (Table 1). Weed species, oil doses and their interaction was significant ($P<0.01$ level) for all the investigated characters in petri and pot experiments (Table 2).

The germination rates were decreased correspondingly increasing doses of lavandin oil in both petri and pot experiments (Table 3). Even no germination after 6 µl dock seeds, 10 µl in wild mustard and wheat seeds in petri experiments, dose of 1.0 kg da^{-1} in wheat seeds, 2.0 kgda^{-1} in dock seeds and 4.0 kg da^{-1} in wild mustard and sunflower seeds in pot experiments were recorded. Germination rate of amaranth seeds were decreased due to increasing dose of essential oil 67.6% and 83.1%, chickpea germination decreased 85.0% and 70.0% in 20 µl and 4.0 kg da^{-1}, respectively. Essential oils have different effects on plant growth one of which is the inhibition of germination (Foe et al., 2002; Barney et al., 2005). Dudai et al., (2000) indicated that monoterpenes, comprising essential oils, inhibit germination of seeds at the lowest level and the plants exposing monoterpene steam have seriously damage. Azirak and Karaman (2008), report that while 3 and 6 µl doses of *Coriandrum sativum, Foeniculum vulgare, Lavandula stoechas, Pimpinella anisum, Rosmarinus officinalis* and *Salvia officinalis* essential oils

didn't affect germination, 10 and 20 µl doses of them influenced adversely to germination of weed seeds; *Alcea pallida, Amaranthus retroflexus, Centaurea solstitialis, Raphanus raphanistrum, Rumex nepalensis, Sinapis arvensis* and *Sonchus oleraceus*. Our results are in accordance with results of Azirak and Karaman (2008).

Table 1. Chemical components of lavandin oil.

Components	RT	Rate (%)
Myrcene	15.3	0.78
Limonene	17.6	0.38
Eucalyptol	18.3	3.23
Ocimen	20.5	1.52
3-octanone	20.8	0.50
Acetic acid hexyl ester	21.7	0.52
Butanoic acid hexly ester	31.0	0.50
Camphor	38.6	6.61
Linalool	39.3	43.65
Linalyl acetate	40.2	24.58
Octadiendimetilasetat	42.2	2.07
Terpineol	43.0	5.43
Borneol	49.7	1.80
Nerayl acetate	50.8	1.21
Geranyl acetate	52.6	2.36
Nerol	47.7	0.72
Gereniol	57.7	2.81
Alpha-bisabolol	58.0	0.94

RT: Retention time

Compare to control, at 20 µl dose root length of amaranth was decreased at the rate of 86.7%. Root length of wild mustard decrease 87.5% with increasing essential oil doses. Roots length of wheat, dock, and amaranth decreased 37.5, 66.4, 91.0%, respectively, with increasing essential oil doses in pot experiments. Likewise, root length chickpea and sunflower increased at 0.5 kg da^{-1} dose, then again decreased in 1.0 kg da^{-1} dose compared with control (Table 4). It was observed roots of chickpea less affected in both experiment. According to Scrivanti et al. (2003), essential oils destroyed cell organelle in root apical meristem of the plant and damaged cell membranes and so went slow root growth.

Averages of stem length of all species generally decreased with increasing essential oil doses in both of experiment. Dock (83.3 %) and wheat (89.5%) were the most decreased with increasing essential oil doses in petri experiment (Tablo 5). Monoterpenes limited oxygen intake prevents germination and plant growth. Penuelans et al., (1996) declared that α-pinene reduced oxygen consumption in soybean cotyledons, and this situation prevent seed germination and plant growth. Topal and Kocaçalışkan (2006), reported juglone which is important component of walnut, decreased 48.1% seedling length in *Sinapis arvensis*, 79.0% in *Cirsium arvense* and 74.9% in *Lamium amplexicaule*. Same researcher notified amount of chlorophyll decrease in parallel increasing doses at the rate of *S. arvensis* 36.6%, *C. arvense* 44.4% and *L. amplexicaule* 51.5%. The same study, stem length of wheat and amount of chlorophyll decreased 11.1% and 20.2%, respectively.

Dry matter rates of amaranth (84%), dock (60.8%) and sunflower seedlings (59.95%) rise with increasing dose of lavandin oil in petri experiment (Table 6). The highest dry matter rate was observed amaranth seedlings in both experiments. Whereas dry matter rates of wild mustard and wheat seedlings decreased with increasing dose of essential oil in petri experiment, dry matter rates of their increased in pot experiment. However, in contrast to our findings, Terzi et al., (2006) reported that juglone reduce development of the cucumber seedlings, according to control, seedlings of applied juglone seeds produces less 18.5 % dry matters. Increased dry matter rate might be related to prevent water intake in seedlings applied essential oils. Similar results were

obtained by Ağar et al. (2006). Their research is reported that allelochemicals affect physiological interactions such as photosynthesis and respiration, germination of seeds, cell divisions, cell development, membrane permeability, and ion exchange. Consequently, allelochemicals are important to overcome of residual problems in crops, to clean soil and interflow contaminated with using intense herbicide. Essential oils, which one of most important of these chemicals, can be used directly instead of herbicides, are the basis of new synthetic herbicides. In this study, germination of weed seeds significantly inhibited reduced at lower dose applications, while germination rates of cultivated species were not adversely affected at same doses.

Table 2. The variance analysis for germination rate, root and stem length and dry matter of rate in petri and pot experiments

VS	DF	Petri				Pot			
		Germination rate MS	Root length MS	Stem length MS	Dry matter rate MS	Germination rate MS	Root length MS	Stem length MS	Dry matter rate MS
Species (S)	5	14255.7**	37.3**	29.1**	1106.9**	10313.1**	338.5**	601.7**	2760.0**
Dose (D)	4	39318.9**	58.2**	48.7**	215.0**	12210.1**	144.8**	484.9**	180.5**
S x D	20	25413.8**	8.4**	8.9**	513.6**	1509.3**	35.2**	69.4**	467.9**
Error	60	12.3	0.1	0.1	1.6	15.0	0.4	0.5	2.1
CV (%)		10.2	18.5	11.7	7.2	9.7	13.8	10.0	8.2

**Significant at P ≤ 0.01; CV: Coefficient of Variation, MS: Mean square

Table 3. Avarage germination rates (%) in petri and pot experiments.

Species	Petri						Pot					
	0 µl	3 µl	6 µl	10 µl	20 µl	Avr.	0 kg da^{-1}	0.5 kg da^{-1}	1.0 kg da^{-1}	2.0 kg da^{-1}	4.0 kg da^{-1}	Avr.
Common Amaranth	53.3 d*	52.0 d	13.2 fg	9.3 gh	9.0 gh	**27.4**	74.0 d	69.3 de	66.7 e	56.0 f	24.0 h	58.0
Dock	16.0 f	4.0 hı	0.0 ı	0.0 ı	0.0 ı	**4.0**	46.7 g	5.3 k-m	4.0 lm	0.0 m	0.0 m	11.2
Wild Mustard	56.0 d	4.0 hı	3.0 hı	0.0 ı	0.0 ı	**12.6**	16.7 ı	12.0 j-l	9.3 j-l	6.0 k-m	0.0 m	8.8
Wheat	89.3 b	4.0 hı	1.3 ı	0.0 ı	0.0 ı	**18.9**	92.0 bc	72.0 de	0.0 m	0.0 m	0.0 m	32.8
Sunflower	100.0 a	90.0 b	80.0 c	26.1 e	5.2 hı	**60.3**	100.0 a	100.0 a	97.8 ab	13.3 ıj	0.0 m	62.2
Chickpea	100.0 a	100.0 a	96.7 a	90.0 b	30.0 e	**83.3**	100.0 a	90.0 c	66.7 e	66.7 e	15.0 ıj	67.7
Average	**69.1**	**42.3**	**32.4**	**20.9**	**7.4**	**34.4**	**71.6**	**58.1**	**40.7**	**23.7**	**6.5**	**40.1**

*Values within a column followed by the same letter or letters are not significantly different at the 1% level

Table 4. Average root lengths (cm) in petri and pot experiments

Species	Petri						Pot					
	0 µl	3 µl	6 µl	10 µl	20 µl	Avr.	0 kg da^{-1}	0.5 kg da^{-1}	1.0 kg da^{-1}	2.0 kg da^{-1}	4.0 kg da^{-1}	Avr.
Common Amaranth	2.10 ef*	1.50 fg	1.09 g-j	0.52ı-k	0.28 k	**1.10**	3.11 gh	2.43 hı	2.40 hı	0.52 kl	0.28 l	**1.75**
Dock	3.49 d	0.47 ı-k	0.00 k	0.00 k	0.00 k	**0.79**	1.19 j-l	0.57 j-l	0.40 kl	0.00 l	0.00 l	**0.43**
Wild Mustard	2.39 e	1.27 gh	0.30 k	0.00 k	0.00 k	**0.79**	1.61 ı-k	1.78 ıj	1.01 j-l	0.92 j-l	0.00 l	**1.06**
Wheat	10.31 a	0.66 h-k	0.10 k	0.00 k	0.00 k	**2.21**	15.27 b	9.55 e	0.00 l	0.00 l	0.00 l	**4.96**
Sunflower	5.57 c	2.59 e	2.18 e	1.11g-ı	0.40 jk	**2.37**	12.39 c	13.35 c	7.18 f	4.02 g	0.00 l	**7.39**
Chickpea	6.22 b	6.40 b	5.46 c	5.48 c	1.03g-j	**4.92**	10.13de	19.75 a	15.37 b	10.89 d	7.80 f	**12.79**
Average	**5.01**	**2.15**	**1.52**	**1.19**	**0.28**	**2.03**	**7.28**	**7.90**	**4.39**	**2.72**	**1.35**	**3.43**

*Values within a column followed by the same letter or letters are not significantly different at the 1% level

Table 5. Averages of stem length in petri and pot experiments (cm)

Species	Petri						Pot					
	0 µl	3 µl	6 µl	10 µl	20 µl	Avr.	0 kg da^{-1}	0.5 kg da^{-1}	1.0 kg da^{-1}	2.0 kg da^{-1}	4.0 kg da^{-1}	Avr.
Common Amaranth	1.93h-j*	1.36 kl	1.67 jk	1.23k-m	0.80m-o	1.40	4.29 h	3.64 hı	2.99 ıj	0.90 lm	0.68 lm	2.50
Dock	2.90 g	0.47 o	0.00 p	0.00 p	0.00 p	0.67	2.89 ıj	3.47 hıj	1.43 kl	0.00 m	0.00 m	1.56
Wild Mustard	1.85 ıj	1.17 lm	0.60 no	0.00 p	0.00 p	0.72	2.31 jk	2.83 ıj	2.99 ıj	1.40 kl	0.00 m	1.91
Wheat	11.16 a	2.15 hı	1.17 lm	0.00 p	0.00 p	2.90	20.82 b	15.37 e	0.00 m	0.00 m	0.00 m	7.24
Sunflower	5.63 b	3.79 f	2.34 h	1.28 kl	1.40 kl	2.89	21.65 b	18.77 c	16.75 d	3.88 hı	0.00 m	12.21
Chickpea	5.31 bc	5.10 cd	4.76 de	4.36 e	1.00l-n	4.11	24.93 a	25.12 a	18.53 c	9.71 f	6.10 g	16.88
Average	**4.80**	**2.34**	**1.76**	**1.15**	**0.53**	**2.10**	**12.82**	**11.53**	**7.12**	**2.65**	**1.13**	**7.05**

*Values within a column followed by the same letter or letters are not significantly different at the 1% level

Table 6. Averages of dry matter rates in petri and pot experiments (%)

Species	Petri						Pot					
	0 µl	3 µl	6 µl	10 µl	20 µl	Avr.	0 kg da^{-1}	0.5 kg da^{-1}	1.0 kg da^{-1}	2.0 kg da^{-1}	4.0 kg da^{-1}	Avr.
Common Amaranth	6.3 o*	10.6 m	12.7k-m	26.1 g	39.3 b	19.0 c	12.5 j	11.6 j	13.1 j	36.8 e	41.9 d	23.2
Dock	8.4 n	21.4 h	0.0 p	0.0 p	0.0 p	5.9 e	15.6 ı	4.3 l	10.7 j	0.0 m	0.0 m	6.1
Wild Mustard	53.1 a	36.5 c	17.0 ı	0.0 p	0.0 p	21.3 b	47.8ab	44.4 c	45.9 bc	48.8 a	0.0 m	37.4
Wheat	15.6 ıj	13.5 j-l	14.5 jk	0.0 p	0.0 p	8.7 d	12.7 j	17.5 hı	0.0 m	0.0 m	0.0 m	6.0
Sunflower	11.5 lm	20.1 h	21.8 h	27.1 fg	28.7 ef	21.9 b	7.3 k	5.0 kl	5.3 kl	11.4 j	0.0 m	5.8
Chickpea	29.9 de	26.7 fg	27.1 fg	27.4 fg	31.7 d	28.6 a	19.5gh	21.1 g	29.5 f	31.2 f	34.8 e	27.2
Average	**21.8**	**21.5**	**15.5**	**13.4**	**16.6**	**17.6**	**19.2**	**17.3**	**17.4**	**21.4**	**12.8**	**17.6**

*Values within a column followed by the same letter or letters are not significantly different at the 1% level

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