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ORIGINAL PAPER

Bio-Herbicidal Effects of Oregano and Rosemary Essential Oils on Germination and Seedling Growth of Bread Wheat Cultivars and Weeds

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Abstract

Allelopathic effect of essential oils found in Origanum onites L. (Ori) (Turkish oregano) and Rosmarinus officinalis L. (Ros) (Rosemary) was tested on five bread wheat cultivars and two weed species. The essential oils were applied at rate of 0, 2, 4, 8 and 16 µL / petri dishes to study their effect on seed germination and seedling growth of wheat cultivars and two weed species; AVEST (Avena sterilis) and SINAR (Sinapis arvensis) commonly found in wheat field. Both essential oils of Ori and Ros caused a generally detrimental effect on seed germination rate, seedling shoot length, seedling root length and seedling fresh weight of wheat cultivars. Ori and Ros oils caused 37 to 87% and 10 to 78% germination inhibition on wheat cultivars, respectively. Mean germination time was extended as the concentration of essential oil was increased. For majority of the traits tested in this study, there was significant interaction between essential oil type and wheat cultivars. Both essential oils suppressed germination rate of the tested weeds. Ori caused 97 to 100 % germination inhibition rate on SINAR, and 26.7 to 84.5 % in AVEST. Ros also caused 85 to % 100 germination reductions on SINAR. Wheat cultivars were less affected compared to weed species suggesting that proper doses of these essential oils could be used as a bio herbicide for weed control. The result of the study demonstrated that essential oils of Ori and Ros have allelopathic potential, presenting a risk or advantage to seed germination and seedling growth of winter and alternative wheat cultivars grown in Turkey.

Keywords: *Bread wheat, essential oil, germination and seedling growth*

1. Introduction

Wheat is the leading crop of Turkish agriculture in terms of the sowing area and gross production. It is cultivated across the diverse environments, ranging from warm lowlands to temperate highlands [1]. Durum wheat (*Triticum durum* Desf.), bread wheat (*Triticum aestivum* L.) and soft wheat (*Triticum compactum* Host.) cultivars or landraces are grown under changing geographical growing conditions of Turkey; such that 85 – 88 % of the wheat produced in Turkey is bread wheat, rest of the wheat produced is durum or 1% soft wheat [1]. Weeds are the main constraints that negatively affect wheat yield across the wheat growing areas of the world as well as Turkey since they utilize water, nutrients and light of the wheat. Weed control especially during early growth stages assures better plant establishment in turn higher yield. Weeds are also shown for their allelopathic effect on the wheat germination and seedling growth [2]. To achieve weed control, increased amount of

chemical herbicides are being utilized every day. Potential risks of chemical herbicides to human health and environment have raised questions. This has resulted in increased consideration to alternative strategies for development of new environment friendly biodegradable compounds, including plant allelochemicals.

Allelopathy is a naturally occurring ecological phenomenon of interference among different organisms such as fungi, viruses, microorganisms and plants. This may be employed for managing weeds, insects, and diseases in field crops. Organisms synthesize secondary metabolites that influence biological and agricultural systems in stimulatory or inhibitory way [3]. Allelopathy involves synthesis of various chemical compounds, known as allelochemicals, released to the environment [4]. Plant allochemicals are non-nutritional and can be synthesized in any plant part such as leaves, flower, stems, roots and seeds. Under favorable environmental conditions, allelochemicals are released into the environment through the processes of volatilization, root exudation, decomposition and/or leaching, thereby affecting the growth of adjacent plants [4, 5]. Crops produce active chemical compounds that ensure the growth of the seedling by allelopathic inhibition of adjacent crops this phenomenon has been known for a long time [6]. Allelopathic effect of some essential oil crops has been investigated in various oil or ornamental plants or crops by varying plant parts [7, 8, 9]. Germination inhibition by essential oils as applied to seed of various crops and weeds has been reported [6, 7, 8, 9, 10]. Terponoids, in particular monoterpenes and sesquiterpenes, are the main components of essential oils responsible for inhibitory effects weed and crops [8, 9, 11].

To our best knowledge there are limited studies on allelopathic effects of essential oil of *Ori* and *Ros* on commercial bread wheat cultivars and harmful weed species germination and seedling growth. In the present study, essential oils of *Origanum onites* L. (*Ori*) and *Rosmarinus officinalis* L. (*Ros*) were evaluated for allelopathic effects on five bread wheat cultivars which are commonly grown in Turkey, and two weeds species AVEST (*Avena sterilis)* and SINAR (*Sinapis arvensis)* commonly found in wheat growing areas of the Turkey. Therefore, the objective of this study was to evaluate alleopathic effects of two different essential oils on germination and seedling growth characteristics of five wheat cultivars and two weed species. In addition, interaction between the essential oil type and wheat genotypes was also investigated.

2. Materials and methods

2.1. Sources of plant materials: This study was conducted at Faculty of Agriculture, Mustafa Kemal University, Hatay, Turkey in 2014 (36°19’29’’N, 36°11’44''E). Bread wheat registered cultivars seeds of ‘Bezostaja-I, Bayraktar-2000 and Tosunbey’ which are commonly grown in Central Anatolia, ‘Karatopak and Sagittario’, which are alternative bread wheat cultivars commonly grown Mediterranean part of Turkey were used as a materials. Seeds of Bezostaja-I, Bayraktar-2000 and Tosunbey’ were provided by Field Crops Central Research Institute, in Ankara, Turkey and ‘Karatopak and Sagittario’ were provided from the Mustafa Kemal University. Weed seeds of *Avena sterilis (*AVEST) and *Sinapis arvensis* (SINAR) were also tested and seeds were collected from the Hatay Province’s wheat growing areas during 2013. Germination and early seedling growth (10 days) of the cultivars and of weeds (14 days) were studied using distilled water (control) and essential oil concentration (doses) at the rate of 2, 4, 8, 16 µL / petri dish containing *Ori* or *Ros*.

2.2. Plant material preparation for the essential oil extraction

Origanum onites (Turkish oregano) (*Ori*) and *Rosmarinus officinalis* (Rosemary) (*Ros*) were collected from Mustafa Kemal University, Faculty of Agriculture medicinal and aromatic plant gardens in Hatay, Turkey. Species were harvested during June, 2012 when the plants were at flowering stage. Plant samples were dried in the shade. The essential oil was extracted from the dried shoots and leaves of samples of two target species (100 g) by hydro distillation method for three hours using Clevenger-type apparatus. Isolated essential oils were stored at 4 - 6 ˚C until used.

2.3. Analysis of essential oils

The GC-MS analyses were performed on a gas chromatograph HP 6890 (Agilent Technologies, Palo, Atla, USA) with electron impact ionization (70 eV). An HP -MS capillary column (50 m x 0.25 mm x 0.2 µm film thickness) was used. Helium was used as a carrier gas (1.4 mL/min). The column temperature was settled as 5 min at 45 ˚C; then at 3˚C/min to 220 ˚C and held for 10 min. The injector and detector temperature were 220 ˚C and 250 ˚C, respectively. Injection was performed automatically. The optimum injection temperature was 220 ˚C and samples of 0.5 µL oil solution in hexane (1:100) were injected in to helium carrier gas. Peak areas and retention times were measured electronically. Identification of the essential oil compounds was achieved by comparing retention times and mass spectra with those of standards in the library [8, 12].

2.4. Germination test for wheat genotypes and weed species

Seeds of each wheat cultivars and none dormant weeds were surface sterilized with 5 % aqueous solution of sodium hypochlorite for three minutes and rinsed with distilled water for 3 × 3 min. For each wheat cultivars and weed species seeds, 0, 2, 4, 8 and 16 µL essential oil/petri dishes (90 mm) were tested for seed germination and seedling growth with the four replicates. To test the inhibitory effect of the essential oils, 25 seeds were placed on two layered filter paper (Whatman no 1) in Petri dishes moistened with 10 mL distilled water/petri dish. Above mentioned amount of essential oils was applied on the small piece of filter paper. Petri dishes were closed immediately and tightly sealed with parafilm to prevent loss of moisture and avoid contamination and then incubated in a germination cabinet (SANYO FOC 225 I, Refrigerated-Incubator, JAPAN). The wheat seeds were allowed to germinate at 20 ± 2 °C in the dark for 8 days [13]. A seed was considered as germinated when the emerging radicle elongated to 2 mm. Germination percentages were recorded every 24 h for 8 days. Rate of germination inhibition was calculated by using following formula:

$$GI = \left[\frac{GC - TG}{GC}\right] \times 100$$

where: GI is rate of germination inhibition (%); GC is germination rate of control treatment; TG is, germination rate in respective essential oil treatment of wheat genotypes or weed species. Mean germination time (MGT) was calculated to assess the rate of germination [14]. The seedlings were thinned to 10 plantlets per Petri dish after the eighth day [15]. Fresh root and shoot length and seedling fresh weight were measured on the tenth day [16]. Seedling growth (shoot and root) inhibition was calculated by using following formula:

$$SGI = [(SGC - \frac{SGT}{SGC})] \times 100$$

where: SGI is rate of growth (%); SGC is shoot or root length of control treatment; SGT is seedling shoot or root length of essential oil treated wheat or weed seedlings.

The same germination procedures were used and measurements were taken for weed species except the germination temperature that was maintained at 25 ± 2 °C in dark and germination percentages were recorded every 24 h for 14 days. A completely randomized design was used with a factorial arrangement of treatments (cultivar and essential oil concentration) with 4 replications and 25 seeds in each replicate. Data were analyzed by 2-way analysis of variance using statistical package MSTAT-C, and differences among the means were compared using Duncan's multiple range test ($P < 0.05$).

3. Result and Discussion

3.1. Yield of essential oil components

Identified essential oil components of *Ros* are presented on Table 1. A total of 17 compounds representing to 87.31 % total compounds was detected in essential oil of *Ros.* The main essential oil components of *Ros* were 1,8-Cineole (21.45 %), Camphor (19.70 %), Borneol (8.58 %) and Linalool (5.88 %). A total of 8 compounds representing 90.74 % of all compounds was detected in essential oil of *Ori.* The main essential oil components of *Ori* were Carvacrol (57.01), γ-Terpinene (8.77 %), Linalool (8.39%), and *p*-Cymene (7.86%). Dudai & et al., (2004) reported the monoterpenes as a very powerful seed inhibitors on wheat seed [17].

Table 1. Percentage composition of the essential oil of *Rosmarinus officinalis* L. (*Ros*) and *Origanum onites* L. (*Ori*)

Essential oil Components	*R. officinalis* (%)	*O. onites* (%)
1,8-Cineole	21.45	-
Linalool	5.88	8.39
Endobornyl acetate	2.44	-
Methyl eugenol	1.02	-
Myrcene	1.90	2.48
α-Terpinene	1.00	2.87
γ-Terpinene	1.07	8.77
Terpinene-4-ol	3.12	2.09
β-Pinene	0.92	-
β-Caryophyllene	0.94	1.27
p-Cymene	3.08	7.86
Borneol	8.58	-
Verbenene	1.79	-
Camphor	19.70	-
6,6-Trimethylbicyclo	1.91	-
1,3-Dimethylbicyclo	8.24	-
Nopol	1.27	-
Carvacrol	-	57.01
Total	**84.32**	**90.74**

3.2. Germination rate and mean germination time of wheat genotypes

Analyses of variance (ANOVA) showed that essential oil, genotype, dose, oil × genotype, oil × dose, genotype × dose interaction were highly significant for the germination

rate. However, oil × genotype × dose interaction was not significant (Table 2). All main effects and interactions were significant for mean germination time (Table 2). All main effects and interactions were significant but oil × dose interaction was not significant for the fresh seedling weight. Oil × genotype and genotypes × dose interactions were not significant but the other main effects and interactions were significant for the root length. Genotype, oil × genotype and genotype × dose interaction were insignificant but other main effects and interactions were significant for the shoot length (Table 2).

Table 2. Analysis of variance for germaination rate (GR), mean germination time (MGT), root lenght (RL), shoot lenght (SL) and fresh seedling weight (FSW) of wheat genotypes.

Variance Source	SD	GR	MGT	RL	SL	FSW
Oil	1	25649**	52,78**	108704**	24604**	0,170**
Genotype	4	2887**	1,39*	3580**	928 ns	0,018**
Dose	4	31033**	28,25**	57195**	35186**	0,038**
Oil*Genotype	4	1934**	1,58**	851 ns	959 ns	0,014*
Oil*Dose	4	3771**	17,55**	4361**	1906**	0,009 ns
Genotype*Dose	16	616**	3,05**	808 ns	417 ns	0,019**
Oil*Genotype*Dose	16	238 ns	1,87**	1247*	1292**	0,011**
Error	150	227	0,41	623	524	0,004

ns: not significant, * significant at 5%, **significant at 1%

The ANOVA performed for each cultivar indicated that germination rate was differently affected by each essential oil and the essential oil by dose interaction (Figure 1). The essential oil of *Ori* and *Ros* significantly inhibited seed germination rate of wheat cultivars compared to respective control. Inhibition of the germination rates were higher for the essential oil of *Ori* and were more pronounced at increased doses (Figure 1). Germination inhibition by 87.1 % using 16 µL and 37.3% using 2 µL *Ori* essential oil was noted in bread wheat cultivars. Germination inhibition rate of *Ros* for wheat cultivars was ranged from 78.5 % (16 µL) to 10.3 % (2 µL). All cultivars showed significant germination rate inhibition after 2 µL essential oil dose of *Ori,* but Sagittoria cv. did not show significant inhibition rate in the control and 2 µL essential oil treatments. Bayraktar-2000 cv. was the least inhibited genotypes at 8 µL *Ros* treatment. The germination inhibition effect of *Ori* essential oil was more evident as the dose rate increased. More specifically, at the highest dose of *Ori* Tosunbey cv. germination rate was 20.5% compared with the control. On the other hand, cv. Karatopak germination rate was totally inhibited at 16 µL of *Ori* (Figure 1.) These results showed that essential oil of *Ori* and *Ros* had inhibition effect on seed germination of the bread wheat cultivars (Figure 1.).

Mean germination rate of cultivars was 94.1 % in control treatments. Essential oil of *Ori* had 87 % inhibition using 16 µL *Ori* treatments. This inhibition rate was 94 % in control and 78 % on 16 µL dose of *Ros*, respectively (Figure 1.). Dudai & al., (2004) reported that monoterpenes such as Carvacrol had very powerful seed germination inhibitors for wheat. Our results also reveal that carvacrol had adverse effect on the germination of wheat cultivars in varying proportions.

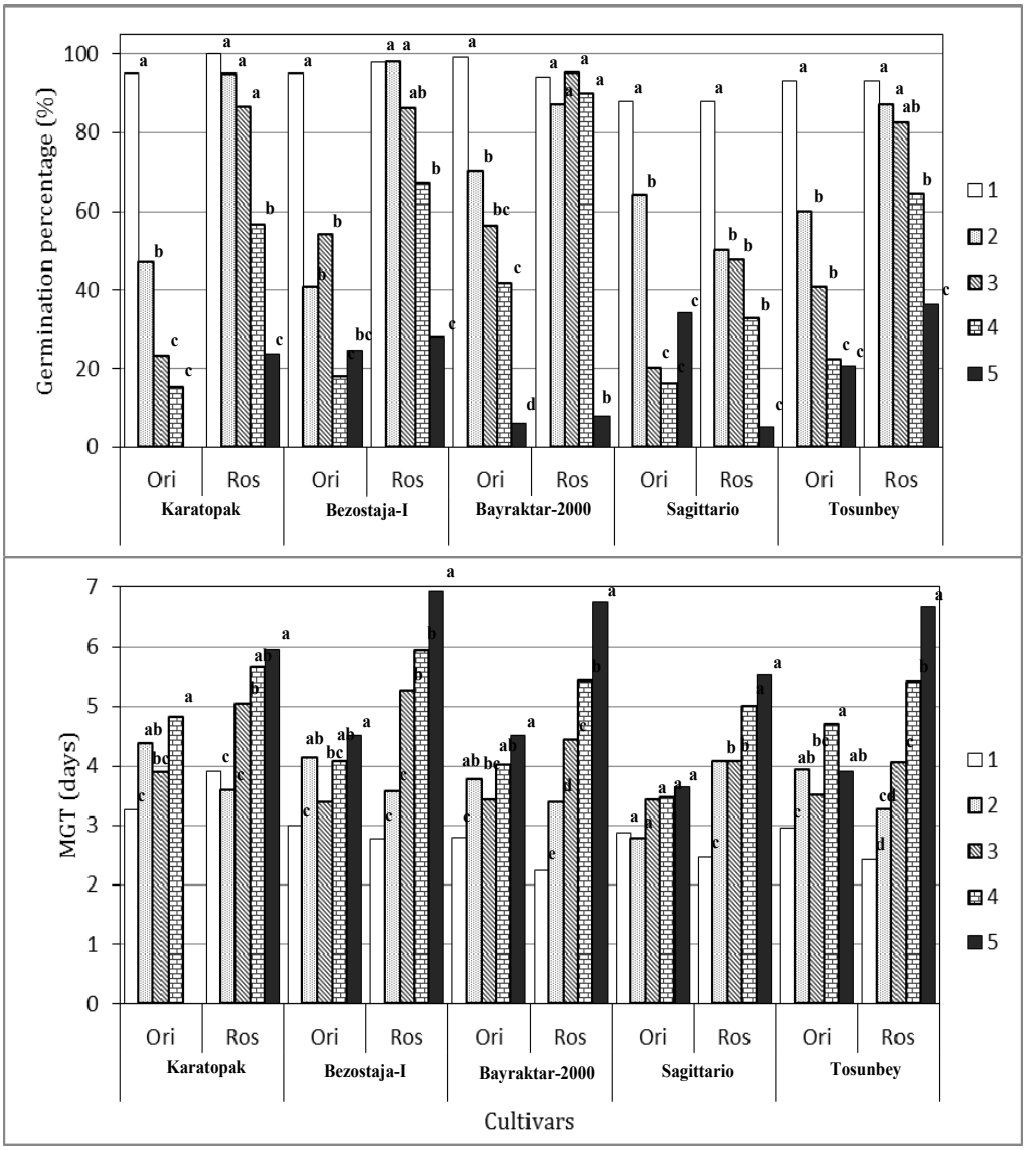

Figure 1. The effect of different dose of *Ori* and *Ros* on germination of bread wheat cultivars (Note; means within each column followed by different letter are significant at P =0.05). Doses, 1. Control; 2. 2 µL; 3. 4 µL; 4. 8 µL; 5.16 µL.

Mean germination time (MGT) was prolonged as the dose of essential oil increased (Figure 1). MGT for the genotypes exposed to *Ori* ranged 2.9 to 4.2 days. But the MGT for the genotypes exposed to *Ros* ranged 2.7 to 6.4 days (Figure 1). There are no previous experimental results representing essential oil effect on MGT in wheat. Our results showed that respective essential oils affected MGT in wheat cultivars variably depending on concentration, type of essential oil and cultivars.

3.3. Effect of essential oil on seedling growth of wheat genotypes

Essential oil of *Ori* and *Ros* significantly reduced seedling shoot length of wheat cultivars compared to respective controls (Table 2). The reduction rate was relatively increased with the increasing dose of both essential oil types. The essential oil of *Ori* proved more

detrimental effect compared to the essential oil of *Ros*. The mean shoot length of wheat cultivars was inhibited by 87 % and 75 %, respectively, by application of essential oil of *Ori* and *Ros* (Table 2). When compared, both oil dose of 4 µL induced 50 mm shoot length reduction using *Ori* essential oil; whereas this reduction was only 20 mm using *Ros* essential oil. Cultivars showed the same inhibitory effect with increasing oil doses of essential oil type (Table 1, 2).

Table 3. The effect of different dose of essential oil on shoot lenght of bread wheat genotypes

		Shoot length (mm)					
Cultivasr	Oils	0	2 µL	4µL	8 µL	16 µL	**Cul.Mean**
Karatopak	*Ori*	104.6 a	88.9 ab	58.5bc	40.8 c	0.0 d	**61.07**
	Ros	90.6 a	84.4ab	57.1bc	56.8 bc	29.0c	
Bezostaja	*Ori*	82.0 a	48.7 b	42.6bc	35.1 bc	16.0c	**58.89**
	Ros	105.7a	101.2 a	89.8a	45.5 b	22.3b	
Bayraktar	*Ori*	95.2 a	89.7 a	53.3b	35.4 bc	13.0c	**69.28**
	Ros	117.3a	108.8 a	88.9ab	68,6 b	22.6c	
Sagittoria	*Ori*	79.0 a	78.5 a	34.2b	24.6 b	24.3b	**60.84**
	Ros	108.4a	91.4 ab	84.9ab	63.1 b	20.0c	
Tosunbey	*Ori*	91.7 a	78.6 a	21.1b	17.0 b	5.7b	**56.69**
	Ros	90.2 a	85.6 a	78.0a	64.0 ab	35.0b	
	Ori	**90.5**	**76.9**	**41.9**	**30.6**	**11.8**	
	Ros	**102.4**	**94.5**	**79.7**	**59.6**	**25.8**	

*) Means within each line followed by different letter are significant at P =0.05.

Essential oil of *Ori* and *Ros* significantly reduced the seedling root length of wheat genotypes compared to respective controls (Table 3). The inhibition was relatively increased with the increasing dose of both essential oils. But root length inhibition rate of *Ori* was higher than the inhibition rate of *Ros*. The root length of wheat genotypes was inhibited by 96 % and 85 % after application of *Ori* and *Ros* type essential oils, respectively (Table 4). Sagittoria cv. was the most effected cultivar as the essential oil type changed especially after the dose of 4 µL. Previous experiments suggest that essential oil effect on various cereal crops [18, 19, 20] including wheat germination [9] inhibition. Our results also showed inhibition differences with respect to germination rate and seedling growth rate of wheat cultivars.

Essential oil of *Ori* and *Ros* significantly decreased the fresh seedling weight of wheat genotypes compared to respective controls (Table 5). The inhibition rate was relatively increased with the increasing dose of both essential oils. The essential oil of *Ori* proved more detrimental and had more allelopathic effect compared to *Ros*. The fresh weights of wheat genotypes decreased by 75 % and 40 %, by the application of essential oil of *Ori* and *Ros,* respectively (Table 2).

Table 4. The effect of different dose of essential oil on root lenght of bread wheat genotypes

		Root length (mm)					
Cultivars	Oils	0	2 µL	4µL	8 µL	16 µL	**Cul.Mean**
Karatopak	*Ori*	106.1a	44.0 b	32. 0 bc	26.5bc	0.0c	**66.34**
	Ros	154.1a	143.6 a	72.0 b	56.4bc	28.7c	
Bezostaja	*Ori*	84.2a	13.6 b	6.8 b	5.1b	4.8b	**50.88**
	Ros	146.1a	109.6 b	80.1 b	36.1c	22.4c	
Bayraktar	*Ori*	113.2a	42.7 b	14.7 bc	11.8bc	4.3c	**60.74**
	Ros	128.5a	101.1ab	96.7 ab	86.6 b	7.8c	
Sagittoria	*Ori*	74.5a	45.1 a	3.9b	3.7 b	2.6b	**41.66**
	Ros	121.9a	52.5 b	52.3 b	47.8 b	12.3c	
Tosunbey	*Ori*	92.8a	16.8 b	13.8 b	8.5 b	5.0b	**52.45**
Karatopak	*Ros*	110.0a	90.6 ab	90.6 ab	65.8 b	30.6c	
	Ori	**94.2**	**32.4**	**14.2**	**11.1**	**3.3**	
	Ros	**132.1**	**99.5**	**78.3**	**58.5**	**20.4**	

*) Means within each line followed by different letter are significant at P =0.05).

Table 5. The effect of different dose of essential oil on fresh seedling weight of bread wheat genotypes

		Fresh seedling weight (mg)					
Cultivars	Oils	0	2 µL	4µL	8 µL	16 µL	**Cul.Mean**
Karatopak	*Ori*	0.196a	0.154a	0.137a	0.121a	0.000b	**0.137**
	Ros	0.205a	0,186ab	0.147ab	0.130ab	0.098b	
Bezostaja	*Ori*	0.153a	0.153a	0.102a	0.097a	0.072a	**0.140**
	Ros	0.185a	0.182a	0.187a	0.129b	0.083c	
Bayraktar	*Ori*	0.182a	0.151a	0.121a	0.094a	0.000b	**0.140**
	Ros	0.185a	0.157b	0.174a	0.155b	0,095c	
Sagittoria	*Ori*	0.161a	0.135a	0.112a	0.094a	0.073a	**0.131**
	Ros	0.222a	0.169a	0.178a	0.136a	0.029b	
Tosunbey	*Ori*	0.123a	0.093a	0.084a	0.066a	0.056a	**0.106**
	Ros	0.155a	0,147a	0.141a	0.123a	0.075a	
	Ori	**0.163**	**0.137**	**0.111**	**0.094**	**0.040**	
	Ros	**0.190**	**0.168**	**0.165**	**0.135**	**0.076**	

*) Means within each line followed by different letter are significant at P =0.05).

3.4. Germination rate of weed species

As the oil type and oil dose changed weeds responded in different way (Figure 2.). Application of 2 µL *Ori* and *Ros* essential oil had the completely harmful effect on SINAR and AVEST. Essential oil dose of 2 - 4 µL in both *Ori* and *Ros* was the detrimental on the SINAR but not the AVEST. AVEST had survived at all doses of *Ros* oil and, showed 16 % germination rate at the highest (16 µL) dose of *Ros*.

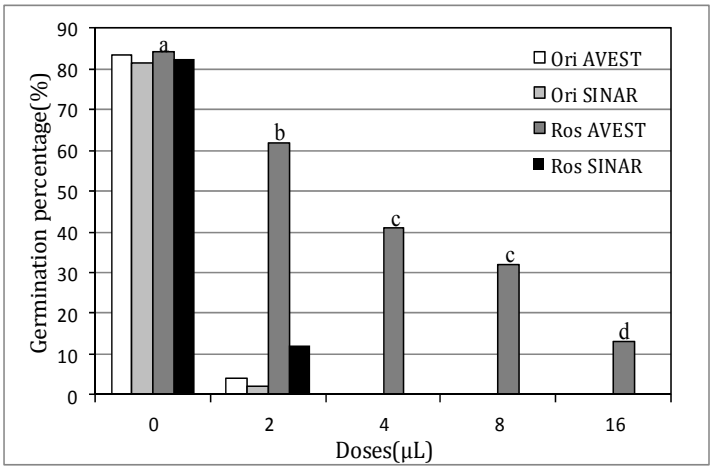

Figure 2. The effect of different dose of essential oil on germination percentage (%) of SINAR (*Sinapis arvensis* L.) and AVEST (*Avena sterilis* L.) (Note; Means within each column followed by different letter are significant at P =0.05).

While germination rate of SINAR was 84.3 % in control treatment, essential oil of *Ori* had the highest inhibition rate on SINAR seeds. The inhibition rate of SINAR was 97 % even at 2 µL dose of *Ori*. The inhibition rate of SINAR was 100 % when the dose of 4 µL of *Ori* was applied. The inhibition rate of AVEST was 51 % in 2 µL dose of *Ros* application, and the inhibition rates increased with the increasing oil dose of *Ros*. The highest dose of 16 µL *Ros* resulted in 64.6 % germination inhibition rate in AVEST. A high inhibitory effect of *Ori* in AVEST and SINAR was observed at the dose of 2 µL or the higher doses. The high inhibitory effect was observed after 2 µL dose of *Ros* in SINAR and after the dose of 4 µL dose in AVEST. It can be concluded that *Ori* essential oil had higher germination inhibitor in AVEST and SINAR as compared to *Ros* essential oil. If essential oil of *Ros* would be used for totally AVEST control, higher essential oil dose of *Ros* should be practiced.

Compared to wheat genotypes and weed species, AVEST (*Avena sterilis*) and SINAR (*Sinapis arvensis*) were more affected as the essential oil type changed and the oil dose increased. It was appeared that using 2 µL/petri dish was lethal dose for the AVEST and SINAR. However, using *Ros* essential oil, the lethal dose could be achieved only after application of more than 16 µL essential oil/petri dish. Turk & Tawaha (2003) reported short-term autotoxicity and possible short-term allelopathy plant parts extract of black mustard (*Brassica nigra* L.) on wild oat (*Avena fatua* L.) [8]. *Brassica nigra* had harmful effects on wild oat including reduced seed germination and emergence. Uremis & al., (2009) reported highest inhibitory effects of *Thymus vulgaris* L. and the lowest inhibitory effects of *Melissa officinalis* on AVEST germination [8]. The essential oil of *Ori* had the potential for use in SINAR and AVEST control. Similar results were reported by Azirak & Karaman (2008) who reported that the essential oil from *Origanum onites* L. showed high inhibitory effects to germination of the *Amarantus retroflexus, Centaurea salsotitialis, Sinapis arvensis, Sonchus oleraceus, Raphanus raphanistrum* and *Rumex nepalensis* [6].

The results of present study confirmed allelopathic activity (inhibition) of essential oils extracted from *Ros* and *Ori* on the investigated weed species and wheat cultivars. The essential oil of *Ori* exhibited more powerful allelopathic effect compared to *Ros* essential oil on the germination and seedling growth of examined wheat cultivars and the weed species. *Ori* or *Ros* essential oil could be practiced as bio-herbicides for SINAR control in wheat but proper doses should be chosen. The results also revealed significant difference in the inhibitory effect of the two essential oil doses against wheat genotypes and weed species. This different response can be attributed to different rates of metabolism [9]. Wheat seeds when

exposed to essential oils were able to metabolize certain monoterpenes. The amount of these metabolized monoterpenes responsible for inhibition of germination seed [20]. Wheat genotypes were affected less compared to weed species showing proper dose of these essential oils could be used as a bio herbicide for weed control. The inhibitory effects especially for germination characteristics depend on the dose, oil type, weed species and wheat genotypes. Germination percentage was also found to be significantly correlated with emergence rate which is an important trait for crop stand establishment and yield [21].

The essential oils are believed to be secure since they breakdown quickly in the natural environment and show low toxicity [6, 8, 9]. In this regard, they differ from synthetic herbicides. They can be used as an environment friendly tool for weed control in field crops; however, they must act selectively, giving no damage to crops that are intended to grow [6]. For this intention, the herbicidal effect of the essential oil should be evaluated both at field level on various cultivars and relevant harmful weed species.

Differential response of various allelochemicals and their concentrations has been reported in pervious experiments. The essential oils used and the dose applied in our study did effect the seed germination of wheat genotypes and some genotypes were more affected. Dudai & al., (1999), reported inhibitory effect of some essential oils on wheat germination [17]. Gitsopoulus & al., (2013) revealed variable responses among cereal crops. Our results confirmed the cultivar differences in terms of germination rate, mean germination time and seedling growth of wheat genotypes [9]. In the present study, the essential oil of *Ori* exhibited the higher phytotoxic effect compared to *Ros* essential oil. The high phytotoxicity of *Ori* may be attributed to carvacrol as the main constitute that had a negative effect on germination of weed species and wheat genotypes [6, 18].

4. Conclusion

Wheat cultivars were less affected compared to weed species suggesting proper dose of *Ori* and *Ros* essential oils could be used as a bio herbicide for SINAR and AVEST control. The result of the study demonstrated that essential oils of *Ori* and *Ros* have allelopathic effects presenting risks or advantages to seed germination and seedling growth of wheat.

More knowledge about bio-degradable herbicides expected to decrease potential human and environmental hazards. The present study results showed that the essential oil of *Ori* and *Ros* could be considered as potential alternative allelochemicals used in weed control as herbicides and they were also suitable for use under organic farming. Furthermore, pot experiments and field studies could provide more useful information concerning the wheat cultivars, weed species and dose of each oil used to achieve more reliable weed control. It appears that there is great variation among wheat genotypes in terms of responding different allelochemicals. Therefore, results of this study should be useful for wheat breeders to improve varieties resistant to specific allelochemicals, which kill other weeds causing yield losses.

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