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COMPARISION OF THE YIELD AND QUALITY PARAMETERS OF CERTAIN 'KEKIK' SPECIES GROWN IN CENTRAL TURKEY

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Abstract: *A collection of oregano, thyme and summer savory plants were seeded and grown in an experimental field at the Central Research Institute for Field Crops in Ankara, Turkey, to investigate the biomass and foliage production, essential oil, and carvacrol and thymol during the years of 2009 and 2010. The following yield parameters were observed and measured with two cuttings from each growing season. The total green herb yield of the two harvests ranged from 17.12 t/ha to 52.74 kg/ha in 2009 and 15.46 t/ha to 69.55 t/ha in 2010. The total dry herb and dry leaf yields were; 4.82-15.37 t/ha and 4.54-21.1 t/ha; and 2.23-511 t/da and 3.10-10.8 t/ha in two successive years, respectively. The average essential oil ratio of the kekik species changed from 1.42% to 6.08% and 1.30-5.43%. Despite most previous studies emphasizing carvacrol as the major constituent of O. onites and O. vulgare var. hirtum species in the natural flora of Turkey, the current study detected thymol (a high of 67.45%) as major a constituent in these plants. CV Carva had the highest content of carvacrol with 58.76 % and 74.71%. Among the studied kekik species only Thymus citriodorus was found to contain geraniol with 49.13% and 36.36% contents.*

Key Words: *Origanum vulgare subsp. hirtum, Carva, Origanum onites, Thymus vulgaris, Varico III, Thymus ciriodorus, Satureja hortensis, Satureja spicigera, fresh and dry herb yield, fresh and drug leaf yield, essential oil components, thymol, carvacrol.*

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1. INTRODUCTION

Turkey is a gene center with an endemism rate of 44.2% *Lamiaceae,* 65.2% *Origanum* sp. and 52.6% *Thymus* sp. and is considered to be one of the largest oregano exporter countries in the world (Biskup and Saez 2002; Kintzios, 2002). Oregano exports to overseas increased threefold in the last decade, of which most were still harvested from wild flora and marketed as unprocessed. Due to the similarity of their odor a number of thyme, oregano and satureja species are simply called as 'Kekik' in Turkey. They are representing *Thymus* with 57 taxa, *Origanum* with 23 taxa, *Satureja* with 14 taxa, *Tymbra* with 4 taxa and *Coridathymus* with one species (Ietswaart, 1980; Davis, 1982; Lawrence, 1984; Kokkini, 1997; Başer et. al. 1993). The common characteristics of these species are their carvacrol and thymol contents. From these 23 *Origanum* species, 14 of them are recorded as endemics of Turkey (Duman et. al. 1996). The major products labeled 'Oregano essential oil' at local markets are produced from the species *O. onites* and *O. vulgare* L. (Baytop, 1999). It's estimated that 90% of exported kekik consists of *Origanum onites* (İzmir kekiği), *O. vulgare* spp. *hirtum* (İstanbul kekiği, kara kekik), O. *minutiflorum* (sütçüler kekiği), O. *majorona* (Beyaz kekik, Alanya kekiği) and O. *syriacum* var. *bevanii* (Suriye kekiği, İsrail kekiği). Oregano water is consumed for gastrointestinal disorders to reduce blood cholesterol and glucose levels as a folk remedy. Oregano oil, rich in carvacrol has also been used as a painkiller for rheumatism and as an antiseptic and analgesic (Aydın et al, 1993; Başer, 1995; Baytop and Başer, 1995; Baytop, 1999; Baser 2008). Even though there have been previous 'kekik' cultivation studies in the coastal regions, this research is believed to give a comparative cultivation on the yield and essential oil parameters among different 'kekik' species grown in Central Anatolia. By means of this study the biomass and Essential oil production of thyme (*Thymus* spp.), oregano (*Origanum* spp.), and summer savory (*Satureja* spp.) growing in the Central Research Institute for Field Crops in Ankara, Turkey, were investigated for the production of essential oils and for the level of carvacrol and thymol during 2009 and 2010 from two cuttings.

2. MATERIAL AND METHODS:

The observations were taken from a two-years old plantation (established in 2007) consisting of the following six different 'kekik' species and two cultivars; *Origanum vulgare* subsp. *hirtum*, *Origanum onites*, *Thymus vulgaris* (a wild population), *Thymus citriodorus*,

Satureja hortensis and *Satureja spicigera* and two cultivars, Carva (*O. vulgare* L. subsp *viridulum* x *O. vulgare* L. subsp. *hirtum*) and Varico III (*Thymus vulgaris*), produced by Delley Samen und Pflanzen AG (Delley Seeds and Plants Ltd.), as references. The cuttings of *Satureja spicigera* were obtained from The Black Sea Agricultural Research Institute. *Satureja hortensis* seedlings, the only annual, were planted every growing season. The field experiments were designed using a completely randomized block design with four replications. Plants were harvested at 50% flowering, the time for optimum biomass and essential oil content (Kitiki, 1997). Fresh weights, dry weights and leaf weights were measured. The unit plot area was 5.28 m² and 66 seedlings were planted in each plot using 40x20 cm spacing. Two harvests were recorded during each growing season in succession over two years as shown in Table.2.1. The first harvests was generally made in mid-June and the second from late August to mid-October in succession over two years.

Table 2.1. The 1st and 2nd harvest dates of the studied species during 2009 and 2010

Species	2009		2010	
	1st	2nd	1st	2nd
Origanum vulgare* subsp. *hirtum Wild	15-17.06.2009	12-15.10.2009	16-17.06.2010	02-03.09.2010
Origanum vulgare* subsp. *hirtum Carva	11-12.06.2009	25-26.08.2009	15.06.2010	31.08.2010
Origanum onites	22-25.06.2009	20-24.08.2009	08.06.2010	16.08.2010
Thymus vulgaris L. Varico III	03-04.06.2009	15-16.10.2009	31.05.01.06.2010	22-23.09.2010
Thymus vulgaris L. wild	01-02.06.2009	19-20.10.2009	02-04.06.2010	19-20.10.2010
Thymus citriodorus	09-11.06.2009	12-15.10.09	11-14.06.2010	22-23.10.2010
Satureja hortensis	22-25.06.2009	20-24.08.09	09.08.2010	27-28.09.2010
Satureja spicigera	11-12.06.2009	25-26.08.09	01-02.07.2010	29-30.09.2010

Essential oils were extracted using distillation and characterized by GC-MS in Ankara University Agricultural Faculty, Medicinal and Aromatic Plants Laboratory. The essential oil extractions were conducted using a hydro distillation method. Dry leaves (100 g) were placed in a distillation apparatus with 2 L of double distilled water and hydro distilled for 3 h. The gas chromatographic analysis of the essential oils was performed with a Hewlett-Packard 6890 N HP-5 series gas chromatograph, under the following conditions: capillary column, (30 m x 0.25 µm); oven temperature program, 60º C raised to 220 º C at a rate of 5

º C/min and then held at 220º C for 20 min; injector and detector temperatures, 240 º C. Helium was used as the carrier gas (1 mL/min). The components of essential oils were identified by comparison of their mass spectra with those in The Adams Library, Wiley GC/MS Library, Mass Finder Library and confirmed by comparison of their retention indices (RRI). The results were analyzed by analyses of variance and ranged by Duncan's multiple range tests (Adams, 2007; Davies, 1990; Jennings and Shibamoto, 1980; Düzgüneş, 1987).

3. FINDINGS AND RESULTS

3.1. Fresh herb yield (t/ha)

Despite the common dry consumption of Oregano and Thyme species, *Satureja hortensis* and *Satureja spicigera* are generally sold fresh in local markets after bunching, especially in The Black Sea Region.

The fresh herb yield parameters of the first and second harvest and their sums are summarized and grouped as tons per hectare in Table 3.1.1. The results were analyzed by an analyses of variance and ranged with Duncan's multiple tests. The fresh herb yield differences were found to be statistically significant at a level of 1% and four different ranging groups were determined in their sum values.

Table 3.1.1. The fresh herb yield of 'kekik' species during 2009 and 2010 (t/h)

Species	2009			2010		
	1st	2nd	Sum	1st	2nd	Sum
O. vulgare subsp. *hirtum* wild	24.34 b AB	19.38 a A	43.72 abAB	30.89 ab AB	**38.66 a A**	69.55 a A
O. vulgare subsp. *hirtum* Carva	**31.72 a A**	**21.02 a A**	**52.74 a A**	**36.61 a A**	31.24 b AB	67.85 a A
O. onites	**11.82 de C**	7.05 bB	**18.87 c D**	14.99 cd D	13.73 c DE	28.72 c CD
T. vulgaris (Var 3)	**10.15 e C**	14.99 aAB	25.14 c CD	15.07 cd D	25.40 b BC	40.48 b BC
T. vulgaris wild	11.46 de C	13.67abAB	25.12 c CD	12.42 cd D	16.30 c CD	28.72 c CD
T. citriodorus	17.04 cd BC	**20.65 a A**	37.69 b BC	17.83 c CD	29.24 b AB	47.07 b B
S. hortensis	**12.20 cde C**	**4.92 c B**	**17.12 c D**	**9.47 d D**	**5.99 d E**	15.46 d D
S. spicigera	**17.64 c BC**	**4.89 c B**	**22.54 c D**	25.30 b BC	16.26 c CD	41.55 b BC
MID (%1)	7.85	10.90	14.12	9.21	9.95	14.52

*Lowercase letters indicates 5%, uppercase letters indicates 1% statistical differences

The highest fresh herb yield was recorded at Carva from the first harvest in 2009 with a total of 52.74 tons per hectare. No statistical difference was found between *O. vulgare* var. *hirtum* and Carva in the fresh herb yield, in 2010. Saruhan et al. 2004 recorded the highest fresh herb yield at *O. vulgare* var. *hirtum* as 30.84 t/ha from 50x30 cm spacing in Ankara. These results support our findings of the total fresh herb yield with 43.72 t/ha and 69.55

t/ha. The narrow spacing and high density of plants per hectare and the record of the sum of two harvests increased the fresh herb yield results. *Thymus citriodorus* followed this by 37.69 t/ha and 47.07 t/ha. When compared with all the results the least fresh herb yield recorded at the annual species, *S. hortensis* with 17.12 t/ha and 15.46 t/ha. Kızıl and Tonçer recorded 3.89-5.96 t/ha fresh herb yields in Diyarbakır ecological conditions from one harvest. *Origanum onites* is a native plant of the Aegean and Mediterranean Coasts (Anonymous, 2011). According to Bayram et al. (1999), 30.70-45.34 t/ha fresh herb yields were recorded on the first year and 26.21-38.14 t/ha on the second year in Izmir, in the Aegean Region. According to other research carried out by Güngör et al. (2005) different eight *O. onites* lines were evaluated in respect to their biomass yield during 1998-2000 in Dereköy (Manisa-Kula, Aegean Region). They had one harvest in 1999 and two harvests in 2000. The fresh herb yield was recorded as follows; 5.20-7.66 t/ha on the first year and 5.60-21.1 3 t/ha and 4.23-16.03 t/ha, for two successive years. According to these results, the fresh herb yield of *O. onites* in Central Anatolia (short growing season and extreme climate compared to Aegean Region) was found to be less than Bayram et al. (1999)'s results but parallel with Güngör et al. (2005)'s results when the both harvests were combined.

3.2. Dry Herb Yield (t/ha)

Dry herb is one of the main yield parameters for 'Kekik' production. The exporters generally purchase the raw material as dried and pre-sifted from the farmers. Also they have become quite good at blending the various kinds of oregano to suit various consumer preferences in other various countries. The levels of essential oil, bulk index, stems and insect fragments are also specified. Bulk processing makes it easier for the product to pass Food and Drug Administration rules in the United States. These kinds of specifications and blends make Turkish oregano preferred in the USA and other world markets (Olivier, 1997). According to analysis of variance results, ten different groupings were found among the species.

Table 3.2.1. The dry herb yield of the 'kekik' species during 2009 and 2010 (t/ha)

Species	2009			2010		
	1st	2nd	Sum	1st	2nd	Sum
O. vulgare subsp. *hirtum* wild	7.474 a AB	7.895 a A	15.37 a A	9.395 a A	11.70 a A	21.10 a A
O. vulgare subsp. *hirtum* Carva	8.624 a A	6.597 a A	15.22 a A	10.80 a A	8.366 c BC	19.17 a A

O. onites	2.674 cd D	1.739 b B	4.409 e D	4.047 c BC	3.995 de E	8.042 d DE
T. vulgaris (Var 3)	2.229 d D	6.315 a A	8.545 c BC	3.944 c BC	8.778 bc BC	12.72 bc BC
T. vulgaris wild	2.772 cd D	5.865 a A	8.637 c BC	3.429 cd C	6.958 c CD	10.39 cd CD
T. citriodorus	4.238 bc CD	7.69 a A	11.93b AB	4.384 c BC	10.36 ab AB	14.75 b B
S. hortensis	2.931 cd D	1.898 b B	4.829 de CD	2.189 d C	2.355 e E	4.542 e E
S. spicigera	5.527 b BC	2.096 bB	7.622 cd CD	6.17 bB	4.865 d DE	11.04 c BCD
MID (%1)	2.225	3.451	4.104	2.371	2.698	4.048

*Lowercase letters indicates 5%, uppercase letters indicates 1% statistical differences

The dry herb yield was determined to be statistically significant at a level of 1%. As shown in Table 3.2.1. the highest dry herb yield was obtained from both *O. vulgare* var. *hirtum* and CV Carva as 15.37-15.22 t/ha and 21.10-19.17 t/ha, in 2009 and 2010 from the sum of two harvests. Rey et al (2002) had a 5-6 t/ha dry herb yield from Carva in Swiss ecological conditions. Simmonet et al. (2013) recorded 2.8 t/ha dry herb yield at Carva from 5 plants/m^2 and Drutu and Trots (2010) 3.52 t/ha max dry herb yield from *O. vulgare* L. When compared with reference studies; 15-20 t/ha dry herb yield from CV Carva in two successive years seems rather high. If the narrow plant spacing (40x20 cm) and the three-fold number of plants in the unit area (13.2 plants/m^2) from total yield of two harvests are considered, it yiels parameters which are in accordance with references. *T. citriodorus* was recorded as one of the most productive species in this research. The dry herb yield of the species was found to be close to *Origanum* sp. at 11.93 t/ha and 14.75 t/ha. There was no significant difference found between wild and cultivar species (CV Varico 3) of *Thymus vulgaris* species in 2009, with 8.63 t/ha and 8.54 t/ha. This statistical grouping changed in 2010, the dry herb yield was recorded at CV Varico 3 12.72 t/ha and 10.39 t/ha at it's wild form. Galambosi (2010) recorded 1.78 t/ha drug herb yield from the annual plantation of Varico I and Varico II (*T. vulgaris*) in Mekkeli, Finland. *S. hortensis* gave 4.82 t/da and 4.54 t/da a sum of dry herb yield over two successive years. *O. onites* gave 4.40 t/ha and 8.04 t/da dry herb yield. The dry herb yield doubled in 2010 in *O. onites*, which is a cold sensitive species compared to the others. For this perennial species it's assumed that economic efficiency is reached within three years.

3.3. Dry Leaf Yield (kg/ha)

There are specifications which need to be met for exportation. Dry leaf yield in 'Kekik' species is very important because less than 1% stem content is preferred during exportation. The oregano leaves should have a pale grayish green leaf color and should be

dried rubbed. The moisture of the leaves should be less than 10% (Anonymous, 2014). The dry leaf yields of the species are given in Table 3.3.1.

Table 3.3.1. The dry leaf yield of the 'kekik' species during 2009 and 2010 (t/ha)

Species	2009			2010		
	1st	2nd	Sum	1st	2nd	Sum
O. vulgare subsp. *hirtum* wild	**3.297 a A**	**5.404 a A**	**8.701 a A**	**5.349 a A**	5.482 a AB	**10.830 a A**
O. vulgare subsp. *hirtum* Carva	1.743bc BC	3.375 b B	5.118 b BC	4.644ab AB	4.928ab AB	9.571 ab A
O. onites	1.569 c BC	**0.838 c C**	2.408 cd D	225.2deCD	2.852 d CD	5.104 d CD
T. vulgaris (Var 3)	**1.159 c C**	2.962 b B	4.121bcCD	2.113deCD	4.126 bc BC	6.239 d BC
T. vulgaris	1.507 c BC	3.071 b B	4.578 b CD	3.344bcdABCD	3.475 cd C	6.818 cd BC
T. citriodorus	2.520ab AB	4.903aAB	7.423 a AB	2.757 cde BCD	**5.685 a A**	8.442 bc AB
S. hortensis	1.701bc BC	**0.536 cC**	**2.237 d D**	**1.613 e D**	**1.490 e D**	**3.103 e D**
S. spicigera	**3.139 a A**	**0.687 c C**	3.826 bcd CD	3.912abc ABC	2.747 d CD	6.660 d BC
MID (%1)	1.270	1.447	2.496	2.147	1.428	2.417

*Lowercase letters indicates 5%, uppercase letters indicates 1% statistical differences

In contrary to fresh herb yield, the wild population of *O. vulgare* subsp. *hirtum* gave the highest dry leaf yield with 8.70 t/ha and 10.83 t/ha over two successive years. The first year results when compared with CV Carva were also found to be statistically different. *T. citriodorus* followed these with a high dry leaf yield close to *Origanum* species 7.42 t and 8.44 t per hectare. *S. hortensis* gave the lowest dry herb yield with 2.23 t/ha and 3.10 t/ha. Kızıl and Tonçer (2001) recorded 0.68 t/ha and 1.03 t/ha dry leaf yield in *S. hortensis* from one harvest. If the first harvests in the present research are taken into account 1.70 t/ha and 1.49 t/ha, the results agree with the previous findings. Güngör et al. (2005) were reported from two harvests in 2000 at 2.04 t/ha and 6.29 t/ha dry leaf yield from *O. onites*, in Dereköy (Manisa-Kula). Compared to Central Anatolia, this area has a mild climate and a long vegetation period. *O. onites* gave a 2.40 t/ha and 5.10 t/ha dry leaf yield for our conditions and supporting the correlation between the two research efforts.

3.4. Essential Oil Ratio (%)

Among over 40 species of oregano the essential oil produced from *Origanum vulgare* is considered to be the most therapeutically beneficial. The essential oil color is pale yellow that turns brown as it ages. The pure essential oil of oregano is a moderate skin irritant and a strong mucus membrane irritant and should not be applied directly to the skin or taken internally unless diluted (Lynde, 2004).

Five different statistical groups were found to be important at a 1% level in 2009 and three in 2010 with regards to their means of essential oils. This ranked from 1.43-6.08% in 2009

and 1.30-5.43% in 2010. As shown in Table 3.4.1. the following essential oil ratios were recorded; 4.56-4.68% in *O. vulgare* var. *hirtum*, 2.7-2.6% in *T. vulgaris*, 1.4-1.3% in *T. citriodorus*, 2.0-2.6% in *O. onites*, 2.4-2.0% in *S. hortensis*, and 1.4-1.7% in *S. spicigera*.

Table 3.4.1. The essential oil ratio (%) of the species in 2009 and 2010

Species	2009			2010		
	1st	2nd	Mean	1st	2nd	Mean
O. vulgare subsp. *hirtum* wild	4.925 b A	4.200 b B	4.565 b B	5.300 a A	4.063 b AB	4.682 b A
O. vulgare subsp. *hirtum* Carva	**6.075 a A**	**6.100 a A**	**6.088 a A**	**6.063 a A**	**4.800 a A**	**5.432 a A**
O. onites	1.838 e CD	2.200dDE	2.020 ef DE	2.825 bc B	2.300 d C	2.565 cd B
T. vulgaris (Var 3)	3.300 c B	3.875bBC	3.588 c C	2.250 c BC	3.313 c B	2.783 c B
T. vulgaris	2.263deBCD	3.075cCD	2.670 d D	3.213 b B	1.950 d CD	2.585 cd B
T. citriodorus	**1.475 d D**	1.375efEF	**1.430 f E**	**1.288 d C**	1**.325 e D**	**1.308 f C**
S. hortensis	2.850 bc BC	1.875deEF	2.362 de D	2.300 bc BC	1.750de CD	2.028 de BC
S. spicigera	1.800 cd CD	**1.050 f F**	**1.428 f E**	2.112 cd BC	**1.200 e D**	1.660 ef C
MID (%1)	1.365	0.956	0.6342	1.247	0.8351	0.7933

*Lowercase letters indicates 5%, uppercase letters indicates 1% statistical difference

Tınmaz et al (2002) screened a large number of *Origanum vulgare* var. *hirtum* wild accessory collected from the Marmara Region of Turkey in accordance with their essential oil contents and their components. 45 accessories had more than 3% essential oil of 61. Bayram et al (1999) determined the main essential oil content of *O. onites* at the first year 2.36-3.11% and the second year 1.74-2.45% in İzmir and Baydar (2002) 2.85% in Isparta Ecological conditions. Both counties are more humid than Ankara with a higher temperature and longer growing periods. These can cause high essential oil formation compared to Ankara ecological conditions. CV Carva has the highest essential oil content among 8 species, with 6.08% and 5.43%. Simmonet et al (2013) determined 7.6% essential oil at Carva in Swiss. These findings supports our results in *Origanum* spp. CV Varico 3 gave a 3.58% and 2.78% essential oil. Carlen et al. (2010) determined to be 4.9% essential oil content in Varico 3 in Swiss ecological conditions. Pank and Krüger (2003) screened thirteen different *Thymus* population with regard to their essential oil ratios and recorded them as 2.3-2.1%. Our essential oil ratios were found to be close to Pank and Krüger's (2003) but behind Carlen et al.'s (2010).

3.5. The Main Essential oil Components of the Species

The essential oil components are affected from the regional temperature differences and seasonal factors. Extreme drought promotes the carvacrol/γ-terpinene formation (Baher, et

al. 2002). The thymol content of early flowering, at the beginning of July, is determined to be higher than that of the harvest in September. The opposite effect was observed for carvacrol (Mastelic and Jerkovic, 2003). Despite most previous studies emphasize carvacrol as the major constituent of *O. onites* and *O. vulgare* var. *hirtum* species in the natural flora of Turkey, the current study detected thymol (a high of 67.5%) as a major constituent in these plants. Carvacrol (5-isopropyl-2-methylphenol) is a phenolic monoterpene presented in the essential oil of the genera *Origanum* and *Thymus* (Baser 2008; Koparal and Zeytinoglu 2005). As shown in Table.3.5.1. CV Carva had a 58.76% mean carvacrol ratio in 2009 and 74.7% in 2010. Carlen et al. (2010) determined 75.0% and Rey et al. (2002) 65.0-95.0% carvacrol at CV Carva.

Table 3.5.1. The mean thymol, carvacrol and γ-Terpinene, p-Cymene and geraniol content of the species (%) in 2009 and 2010.

Species	2009			2010		
	thymol	**carvacrol**	*, **, ***	**thymol**	**carvacrol**	*, **, ***
O. vulgare subsp. *hirtum* wild	**54.71**	0.93	21.56*	**52.67**	0.99	24.41*
O. vulgare subsp. *hirtum* Carva	7.19	**58.76**	9.79*	2.52	**74.71**	7.58*
O. onites	**67.45**	5.24	7.47*	**57.78**	3.33	11.0*
T. vulgaris (Var 3)	**49.53**	2.50	21.95**	**59.81**	3.37	13.92**
T. vulgaris	**62.35**	3.38	11.05**	**49.83**	2.53	23.45**
T. citriodorus	9.41	1.99	**40.32****	1.96	-	**36.36****
S. hortensis	0.63	**56.22**	27.40*	0.29	**59.99**	23.99*
S. spicigera	0.98	**47.74**	12.19*	1.02	**46.92**	16.97*

*γ-Terpinene, **p-Cymene, ***geraniol

These values were close to the amounts of the second harvest. Tınmaz et al (2002) screened a large number of *Origanum vulgare* var. *hirtum* wild accessory collected from Marmara Region of Turkey. 45 accessories had more than 3% essential oil of 61. The carvacrol ratio changed between 7.5-82.9% and the thymol 0.3-60.1%. When the same plant material was cultivated; the carvacrol ratio changed between 5.3-88.6% and thymol 0.3-68.0%. A slight increase of essential oil was recorded from 56 accessories when they were cultivated at field conditions. The major constituent in *T. citriodorus* was geraniol 38.34%, 14.6% citral (geranial) and 11.1% z-citral (neral). Omidbaigi et al (2005) determined 54.4 % geraniol, 13.9 % geranial and 10.1% neral from the cultivated *T. citriodorus* plants in Iran. Baser et al. (2004) reported that wild types of *S. hortensis* grown in the eastern regions of Turkey contain thymol while cultivated S. hortensis grown in western regions contain carvacrol. In

this study, a high amount of carvacrol was detected from the cultivated *S. hortensis* with 56.22% and 59.99%. Eminagaoglu et al. (2007) determined 42.5% carvacrol, 0.3% thymol from *Satureja spicigera* collected from the Artvin province, Black Sea Region, of Turkey. Despite the less rainfall and drought-like weather conditions in Ankara, *S. spicigera* gave 47.74% and 46.92% carvacrol and 0.98 and 1.02% thymol content, as compared more than that grown in Black sea Region. The thymol contents of the *Thymus vulgaris* both wild and CV Varico 3 were 62.35-49.83% and 49.53-59.81%, respectively.

Our data supports the concept that plant selection and plant breeding could be used to increase yield of the plants and their constituents such as carvacrol, thymol and γ – terpinene showing anti-microbial, antioxidant, antiseptic and anti-inflammatory activity. By means of this research, *Thymus citriodorus*, grown mostly as an ornamental, was cultivated for the first time at field conditions in Turkey, and their yield and quality parameters were recorded. Due to its high biomass (11.93-14.75 t/ha total dry herb) and high essential oil content (1.43-1.30%), it could be considered a good source of lemon odor compared to *Melissa officinalis* (0.01-0.03%) and *Cymbopogon winterianus*. All *Origanum* species gave a high yield and high essential oil ratio. They had an excellent regeneration ability and one more harvest could be obtained (3rd), if irrigated. In *Satureja hortensis* cultivation one harvest seems to be favorable. Since the plants became a wood-like structure and tended to flower and form seed buds, after the first post-harvest. This reduces leaf biomass.

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