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Effects of different levels of water and nitrogen applications on the yield and quality of oregano (*Origanum onites* L.)

İzmir Kekiği (*Origanum onites* L.)'nde farklı su ve azot uygulamalarının verim ve kalite üzerine etkileri

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ABSTRACT

Objective: The objective of this study was to reveal the changes that will occur as a result of different water and nitrogen applications in the drug herb yield, drug leaf yield and essential oil ratios of Tayşi 2002, Ceylan 2002 cultivars belonging to oregano (*Origanum onites* L.).

Material and Methods: In order to meet the objective given above, a study was conducted in Bornova ecological conditions in 2012 and 2013 and the varieties (Tayşi 2002, Ceylan 2002) of the oregano (*Origanum onites* L.) plants developed in the Department of Field Crops, Faculty of Agriculture were used. Experiments included 4 different (S1,S2,S3,S4) irrigation applications along with the 2 different nitrogen applications 80 kg/ha nitrogen (N80) and nitrogen-free (N0). The data obtained in two years (2012-2013) were then evaluated.

Conclusion: As a result, on the study it was found that nitrogen applications alone did not have an effect. It was also determined that the yield values increased with the increase in the amount of irrigation applied, but the essential oil ratios decreased.

Keywords: Drug herb yield, essential oil ratio, nitrogen, *Origanum onites* L., Oregano

ÖZ

Amaç: Bu çalışmanın amacı, İzmir kekiği (*Origanum onites* L.) bitkisine ait olan Tayşi 2002, Ceylan 2002 çeşitlerinin drog herba verimi, drog yaprak verimi ve uçucu yağ oranlarında farklı su ve azot uygulamaları sonucunda meydana gelecek değişikliklerin ortaya konmasıdır.

Materyal ve Yöntem: İzmir kekiği (*Origanum onites* L.) bitkisine ait, Ege Üniversitesi Ziraat Fakültesi Tarla Bitkileri Bölümü'nde geliştirilmiş olan çeşitlerin (Tayşi 2002, Ceylan 2002) kullanıldığı araştırma, 2011-2013 yılları arasında Bornova ekolojik şartlarında gerçekleştirilmiştir. 4 farklı (S1,S2,S3,S4) su uygulaması gerçekleştirilirken, 8 kg/da azot (N_8) ve azotsuz (No) olarak 2 ayrı azot uygulaması yapılmış, 2 yıllık (2012-2013) veriler değerlendirilmiştir.

Sonuç: Sonuçta azot uygulamalarının tek başına bir etkisinin olmadığı görülmüştür. Uygulanan su miktarının artmasıyla verim değerlerinin arttığı fakat uçucu yağ oranlarının azaldığı saptanmıştır.

Anahtar sözcükler: Drog herba verimi, uçucu yağ oranı, azot, *Origanum onites* L., İzmir kekiği

INTRODUCTION

Today, the popularity of medicinal and aromatic plants has increased and continues to increase due to the search for natural raw materials by many sectors. Due to its geographical location, our country is very rich in medicinal and aromatic plants and is the homeland of many plants. An average of $145 thousand worth of medicinal plants were exported from our country between 2009 and 2014 (TUIK, 2014). However, most of this demand is met by collecting from the natural flora, since its cultivation is not widespread. This, in turn, put pressure on the flora and caused the decline of some species. Thus, it became clear how important breeding is.

Origanum, which is one of the most important genera belonging to the Ballıbabagiller (Labiateae: Lamiaceae) family, grows naturally in 23 species and 27 taxa in our country. This genus has 41 species and 52 taxa in the world (Davis, 1982). Oregano (*Origanum onites* L.), especially in the Aegean and Mediterranean Regions, is 1750 m above sea level. It spreads naturally in regions up to altitude (Baydar & Arabacı, 2013). The fact that 60% of these 52 taxa grow in Turkiye and this is indicator that our country is the gene center of Origanum species (Başer, 2001).

Oregano, a Mediterranean herb, is found in the flora of Western Anatolia in our country. Oregano includes 2-3% essential oil. This oil contains carvacrol as a phenol derivative (Baytop, 1999). Its essential oil is used as antioxidant, antibiotic, antibacterial, muscle relaxant, stomachic, carminative, diaphoretic, expectorant, stimulating the onset of menstruation, strengthening the body, painkiller, nerve strengthening and against colds (Kintzios, 2001; Damien Dorman et al., 2003; Dadalioglu & Akdemir Evrendilek, 2004; Preuss et al, 2005; Calucci et al., 2005). It is also consumed as a spice (Akgül, 1993; Ceylan et al., 1999). It is considered among the thyme species that have economic importance especially in Europe and America (Bayram et al., 1998). It is among the most exported medicinal and aromatic plants in the world. In our country, plants collected from natural flora have been exported uncontrolled for many years. However, later on, although uncontrolled collection is economical, it is difficult to obtain quality and standard products in this way, and because the conditions for post-collection processing, storage and transportation cannot be adequately met, efforts to expand agriculture have started. It has been reported that 80% of the oregano, which is still exported, is produced under field conditions and 20% is collected from nature (Bayram et al., 2010). According to TUIK data, the average cultivation area in our country between 2009 and 2013 is 8629 ha. An average of 11945.6 tons of production was made in this area and a yield of 1370 kg/ha was obtained.

The amount of water and nitrogen in the soil are the two most important factors in maintaining many metabolic events in plants. While optimum water demands and nitrogen needs of plants have been determined in many cultivated plants, researches are continuing in plant species cultivated for medicinal and aromatic purposes. The most important feature that distinguishes the studies on the subject from cultivated plants is that there is an inverse relationship between the factors affecting plant growth and productivity and the factors affecting essential oil production. In this context, it is important to examine the relations between the productivity of the oregano plant and the production of essential oil by considering the soil moisture and nitrogen content. Therefore, in this study, in which Tayşi 2002 and Ceylan 2002 cultivars were used as plant material, it was determined as the main objective to reveal the effect of soil water content and nitrogen amount on the yield and essential oil amount of oregano, as the most important agricultural factors affecting plant productivity.

MATERIAL and METHODS

The research was carried out in the experimental field of Ege University Faculty of Agriculture, Department of Agronomy in Bornova in 2011, 2012 and 2013. In this study, the data for the years 2012 and 2013 are evaluated. Ceylan 2002 and Tayşi 2002 cultivars of *Origanum onites*, developed by Ege

University Faculty of Agriculture, Field Crops Department and registered in 2002, constitute the material of this study. From these two cultivars, Tayşi 2002 is carvacrol type, Ceylan 2002 is thymol-carvacrol type. The experiment was set up according to the randomized blocks design with 2 factors and 3 replications. For each variety, the split plots were planted in trial order. As the first factor, 4 different levels of irrigation were applied. These applications, namely S1, S2, S3, and S4, are tabulated in Table 1.

Table 1. Irrigation amount (mm)

Çizelge 1. *Sulama miktarı (mm)*

Year	İrrigation Applications			
	S1	**S2**	**S3**	**S4**
2012	378	806	1103	1307
2013	411	787	1247	1530

The specified water doses were provided by the drip irrigation system installed in the experiment, taking into account the precipitation, and each water dose was followed by a tensiometer placed at the beginning of the parcels belonging to the applications. Irrigation applications were started every year in May-June, while was ended when the rains started in October.

As the second factor, two different applications, nitrogen-free and 80 kg/ha N, were carried out in nitrogen application. The first fertilization was made in the form of ammonium sulfate ($(NH_4)_2SO_4$) at 40 kg/ha to the soil before planting in the field, and the second fertilization was made in the form of ammonium nitrate (NH_4NO_3) at 40 kg/ha after the first harvest. Seeds were planted in the nursery, and the seedlings that took root and developed were transplanted into the field at 40x20 cm planting norm. In Bornova district where the experiment was conducted, the average temperature was 17.7^oC in 2011, 18.6^oC in 2012 and 18.5^oC in 2013. The lowest air temperatures were in January of the first two years and were measured at 9.0 and 6.8^oC, respectively. In the third year, the lowest temperature was determined as 8.5^oC in December. The highest temperatures were 28.9 and 30.1^oC in July for the first two years, respectively, and 28.7^oC in August of the third year. The total amount of precipitation was 561.3 mm in 2011, 799.3 mm in 2012, and 854.7 mm in 2013 was measured. Average relative humidity values were determined as 55.2% in 2011, 58.2% in 2012, and 57.1% in 2013. While the lowest relative humidity values were 40.2% and 39.5% in August in the first two years, they were in July with 42% in the third year. The highest values were measured in January with 69.8% in the first year, in December with 71.4% in the second year, and in January with 70.9% in the third year.

The soil of the experimental area has clay loam texture at 0-20 cm and 20-40 cm depths. This alluvial soil structure, which represents the Bornova plain, has a very heavy soil quality. The pH value of 8.2, determined at a depth of 0-20 cm of the experimental area, shows that the soil of the research area is moderately alkaline on the surface, and the pH value of 7.8 at a depth of 20-40 cm shows that it is slightly alkaline. Lime detected up to a depth of 40 cm indicates that the soil is rich in this substance and that it is classified as lime. It was determined that it is poor in organic matter, moderate in total nitrogen, poor in useful phosphorus and rich in beneficial potassium (Kovancı, 1990).

Before transplanting the seedlings in the field, fertilizer application in the form of ammonium sulfate was applied to the determined plots. Fertilizer was applied in the form of ammonium sulfate ($(NH_4)_2SO_4$) at 40 kg/ha in March of the second and third years, and in the form of ammonium nitrate (NH_4NO_3) at 40 kg/ha after the first forms. Controlled irrigation was carried out with the drip irrigation system installed in the experimental area. Tensiometers, to measure the soil moisture, were placed at the beginning of each irrigation application in the experiment. In the first year, the growth and development of the plants in the field were meticulously followed and irrigation, hoeing and weed control were carried out when necessary. However, since the development of plants in the first year is slow and limited, the initial data obtained on

the 1st of November 2011 were not taken into account. The pre-harvest heights of the plants that have reached harvest maturity and have completed their flowering were measured 8-10 cm above the soil surface. In the second year, the first harvest was made on the 4th of June 2012 and the second harvest was achieved on 31th of October, 2012. In the experiments, plant related characteristics such as height, drug herb ratio, drug herb yield, drug leaf ratio, drug leaf yield, dry matter ratio, dry matter yield were determined. After the harvest, the maintenance processes of the experimental plants were continued. The plant samples were subjected to essential oil analysis in the medicinal plants laboratory for the determination of their quality properties. The essential oil content was determined volumetrically by Neo-Clevenger apparatus in drug leaf samples dried at 35ºC. It is given as milliliter/ 100 grams (%) on air dried (Witchtl, 1971).

The yield and quality characteristics obtained in the experiments were evaluated with the TARIST package program, according to the randomized block design with 3 replications and 2 factors, in accordance with the split plots experimental design for each cultivar (Açıkgöz, 1993).

RESULTS and DISCUSSION

Drog herb yield (kg/ha)

The effects of different irrigation and nitrogen dose applications on the drug herb yield in Tayşi 2002 are given in Table 2.

Table 2. The effects of different irrigation and nitrogen dose applications on the drug herb yield in Tayşi 2002 cultivar (kg/ha)
Çizelge 2. *Tayşi 2002 çeşidinde farklı su ve azot dozu uygulamalarının drog herba verimi üzerine etkileri (kg/ha)*

İrrigation	2012							2013						
	Nitrogen (kg/ha)													
	1.harvest			2.harvest			Annu. Total	1.hasat			2.hasat			Annual Total
	0	80	$\bar{X}$	0	80	$\bar{X}$		0	80	$\bar{X}$	0	80	$\bar{X}$	
S1	6096	11000	**8548**	1759	1603	**1681b**	**10229**	2601	3243	**2922**	1027	1866	**1447**	**4369**
S2	6606	5980	**6293**	1243	1531	**1387b**	**7680**	3147	4222	**3685**	2139	1456	**1798**	**5482**
S3	8042	11245	**9644**	2227	1663	**1945b**	**11589**	3995	7272	**5634**	1777	2044	**1911**	**7544**
S4	5264	8656	**6960**	3240	3859	**3550a**	**10510**	7582	5469	**6526**	1984	1852	**1918**	**8444**
X	**6502b**	**9220a**	**7861**	**2117**	**2164**	**2141**	**9877**	**4331**	**5052**	**4691**	**1732**	**1805**	**1769**	**6460**

OVERALL TOTAL

İrrigation	2012			2013		
	Nitrogen (kg/ha)					
	0	80	$\bar{X}$	0	80	$\bar{X}$
S_1	7855	12603	**10229**	3628	5109	**4369**
S_2	7849	7511	**7680**	5286	5678	**5482**
S_3	10269	12908	**11589**	5772	9316	**7544**
S_4	8504	12515	**10510**	9566	7321	**8444**
Overall Average	**8619**	**11134**	**9877**	**6063**	**6856**	**6460**
LSD(1.hst)	N*:2617.88			N.S		
LSD(2.hst)	İrrigation*:1421.34			N.S		
LSD(AnnualTotal)	N.S			N.S		

*: significant at the 5% level, N.S.:not statistically significant

According to Table 2, in the first harvest of 2012, nitrogen application had an effect of 5% on drug herb yield while the average drug herb yield of the plots without nitrogen was 6502 kg/ha, the average drug herb yield value of the nitrogen applied plots was 9220 kg/ha. There are two separate statistical levels here. In the second harvest in the same year, irrigation application had a 5% significant effect on drug herb yield. The highest drug herb yield was measured in S4 irrigation application as 3550 kg/ha and formed the first statistical group. In 2012, S4 irrigation application and N8 nitrogen application stand out differently from other applications. Drog herb yield was insignificant and was not affected by irrigation and nitrogen applications in both harvests of 2013. When the average drug herb yields of each harvest were examined, it was determined that the average drug herb yield was 7861 kg/ha in the first harvest of 2012 and 2141 kg/ha in the second harvest. While this value was 4691 kg/ha in the first harvest of 2013, it became 1769 kg/ha in the second harvest. It is seen that the drug herb yield values measured in the second harvests are lower than those measured in the first harvests.

Table 3 summarizes the effects of different irrigation and nitrogen dose applications on drug herb yield in Ceylan 2002 cultivar. In Table 3, it is seen that irrigation application affects drug herb yield only in the second harvest of 2013. It was observed that the yield of drug herb increased as the amount of water applied increased. The highest average drug herb yield (4097 kg/ha) was found in S4 irrigation application, secondly in S3 irrigation application (3742 kg/ha). These two values formed the first statistical group. The yield value measured in the S3 irrigation application (3742 kg/ha) and the yield value measured in the subsequent S2 application (2482 kg/ha) formed the second group.

Table 3. The effects of different irrigation and nitrogen dose applications on the drug herb yield in Ceylan 2002 cultivar (kg/ha)
Çizelge 3. *Ceylan 2002 çeşidinde farklı su ve azot dozu uygulamalarının drog herba verimi üzerine etkileri (kg/ha)*

İrrigation	2012							2013						
	1.harvest			2.harvest			Annual Total	1.harvest			2.harvest			Annual Total
	Nitrogen (kg/ha)							Nitrogen (kg/ha)						
	0	80	X̄	0	80	X̄		0	80	X̄	0	80	X̄	
S1	7573	10270	**8922**	2350	2038	**2194**	**11116**	11017	12350	**11684**	1527	2247	**1887c**	**13571**
S2	6700	8967	**7834**	1295	2412	**1854**	**9687**	9453	9276	**9365**	2749	2214	**2482bc**	**11846**
S3	13111	7783	**10447**	3775	2714	**3245**	**13692**	8941	10798	**9870**	4240	3244	**3742ab**	**13612**
S4	7032	10683	**8858**	3541	5745	**4643**	**13501**	8028	10276	**9152**	4247	3947	**4097a**	**13249**
X̄	**8604**	**9426**	**9015**	**2740**	**3227**	**2984**	**11999**	**9360**	**10675**	**10017**	**3191**	**2913**	**3052**	**13069**

OVERALL TOTAL

İrrigation	2012			2013		
	Nitrogen (kg/ha)					
	0	80	X̄	0	80	X̄
S1	9923	12308	**11116**	12544	14597	**13571**
S2	7995	11379	**9687**	12202	11490	**11846**
S3	16886	10497	**13692**	13181	14042	**13612**
S4	10573	16428	**13501**	12275	14223	**13249**
OverallAverage	**11344**	**12653**	**11999**	**12551**	**13588**	**13069**
LSD(1.hst)	N.S.			N.S.		
LSD(2.hst)	N.S.			İrrigation*:1427.87		
LSD(AnnualTotal)	N.S.			N.S.		

*: significant at the 5% level, N.S.:not statistically significant

Ceylan (1976) found the average drug herb yield as 1138-3187 kg/ha. Uyanık Güngör et al. (2005), 1586-2939 kg/ha in the first year, 2699-8033 kg/ha in the second year, 2045-6293 kg/ha in the second year, İpek (2007), 7832-7397 kg/ha in *Salvia officinalis* L., Ekren et al. (2011), 9338 kg/ha in *Salvia officinalis* L., 16126 kg/ha in *Salvia fruticosa* Mill.

The drug yields of Tayşi 2002 cultiva, optained in this study, were higher than Ceylan (1976), the first year data of Uyanık Güngör et al. (2005) was higher, the second year data was lower than that of İpek (2007). It was seen that the first harvests were compatible with the data of. The second harvests were lower than that of Ekren et al 2011.

The drug herb yield values of Ceylan 2002 cultivar were found to be lower than the others, consistent with the data of the researcher Ceylan (1976).

Drog leaf yield (kg/ha)

In Table 4, the effects of different irrigation and nitrogen dose applications on the drug leaf yield of Tayşi 2002 cultivar are given. When Table 4 is examined, it is seen that the effect of irrigation application on drug leaf yield in the second harvest of 2012 is significant at the level of 5%. As a result of the statistical analysis, two groups were formed. The highest drug leaf yield was determined as 2033 kg/ha in S4 application and formed the first statistical group. The second group was 933 kg/ha obtained in S3 application, 697 kg/ha obtained in S1 irrigation application and 697 kg/ha obtained in S2 irrigation application, respectively. In other harvest periods and in terms of annual total yield, trial factors did not significantly affect drug leaf yield.

Table 4. The effects of different irrigation and nitrogen dose applications on the drug leaf yield in Tayşi 2002 cultivar (kg/ha)

Çizelge 4. *Tayşi 2002 çeşidinde farklı su ve azot dozu uygulamalarının drog yaprak verimi üzerine etkileri (kg/ha)*

İrrigation	2012							2013						
	1.harvest			2.harvest			Annual Total	1.harvest			2.harvest			Annual Total
	Nitrogen (kg/ha)							Nitrogen (kg/ha)						
	0	80	X̄	0	80	X̄		0	80	X̄	0	80	X̄	
S1	3004	3494	**3249**	661	732	**697b**	**3946**	1722	2181	**1952**	651	1293	**972**	**2924**
S2	2732	3438	**3085**	518	625	**572b**	**3657**	2044	2653	**2349**	1476	1093	**1285**	**3633**
S3	2881	4676	**3779**	1031	834	**933b**	**4711**	2618	4722	**3670**	1255	1327	**1291**	**4961**
S4	2187	2286	**2237**	1783	2282	**2033a**	**4269**	5046	3635	**4341**	1382	1162	**1272**	**5613**
X̄	**2701**	**3474**	**3087**	**998**	**1118**	**1059**	**4146**	2858	3298	**3078**	1191	1219	**1205**	**4283**

OVERALL TOTAL

İrrigation	2012			2013		
	Nitrogen (kg/ha)					
	0	80	X̄	0	80	X̄
S1	3665	4226	**3946**	2373	3474	**2924**
S2	3250	4063	**3657**	3520	3746	**3633**
S3	3912	5510	**4711**	3873	6049	**4961**
S4	3970	4568	**4269**	6428	4797	**5613**
Overall Average	**3699**	**4592**	**4146**	**4049**	**4517**	**4283**
LSD(1.hst)	N.S.			N.S.		
LSD(2.hst)	İrrigation*:846.94			N.S.		
LSD(Annual Total)	N.S.			N.S.		

*: significant at the 5% level, N.S.:not statistically significant

The effects of different irrigation and nitrogen dose applications on the drug leaf yield of Ceylan 2002 cultivar are given in Table 5. As seen from the table the trial factors did not have any significant effect on drug leaf yield in the first harvests of both years. However, it was observed that the İrrigation xN interaction in the second harvest of 2012 and the application of different doses of irrigation in the second harvest of 2013 affected the drug leaf yield at the 5% significance level.

Considering the second harvest data of 2012, in which the İrrigationxN interaction was significant, the highest drug leaf yield was obtained from the combination of 3091 kg/ha and S4N8, followed by the combination of S3N8 with 2115 kg/ha, S4N0 with 1964 kg/ha, and S3N8 with 1273 kg/ha. The lowest drug leaf yield was obtained from the combination of 490 kg/ha and S2N0. Accordingly, it is seen that the most frequently irrigated (S4) and nitrogen applied (N8) plots have the highest drug leaf yield (Table 5).

Table 5. Effects of different irrigation and nitrogen dose applications on drug leaf yield in Ceylan 2002 cultivar (kg/ha)
Çizelge 5. *Ceylan 2002 çeşidinde farklı su ve azot dozu uygulamalarının drog yaprak verimi üzerine etkileri (kg/ha)*

İrrigation	2012							2013						
	1.harvest			2.harvest			Annual Total	1.harvest			2.harvest			Annual Total
	Nitrogen (kg/ha)							Nitrogen (kg/ha)						
	0	80	X̄	0	80	X̄		0	80	X̄	0	80	X̄	
S1	3346	3834	**4619**	1042 bc	1015b	**1029**	**4619**	6690	6800	**6745**	1148	1572	**1360 b**	**8105**
S2	2049	3008	**3325**	490 c	1103b	**797**	**3325**	5372	5337	**5355**	1861	1428	**1645 ab**	**6999**
S3	4628	4592	**6304**	2115 a	1273b	**1694**	**6304**	5940	5705	**5823**	2840	2111	**2476 a**	**8298**
S4	3562	3836	**6227**	1964 ab	3091a	**2528**	**6227**	4672	6300	**5486**	2537	2308	**2423 a**	**7909**
X̄	**3396**	**3818**	**5119**	**1403**	**1621**	**1512**	**5119**	**5669**	**6036**	**5852**	**2096**	**1855**	**1976**	**7828**

OVERALL TOTAL

İrrigation	2012			2013		
	Nitrogen (kg/ha)					
	0	80	X̄	0	80	X̄
S1	4388	4849	**4619**	7838	8372	**8105**
S2	2539	4111	**3325**	7233	6765	**6999**
S3	6743	5865	**6304**	8780	7816	**8298**
S4	5526	6927	**6227**	7209	8608	**7909**
Overall Average	**4799**	**5438**	**5119**	**7765**	**7890**	**7828**
LSD(1.hst)	N.S.			N.S.		
LSD(2.hst)	İrrigationrxN*:959.76			İrrigation*:865.58		
LSD(AnnualTotal)	N.S.			N.S.		

*: significant at the 5% level, N.S.:not statistically significant

When the second harvest data of 2013, in which only irrigation application was important, were examined, it was seen that the highest yield was found in the S3 application with 2476 kg/ha, followed by 2423 kg/ha in the S4 application and 1645 kg/ha in the S2 application. If the lowest yield value was 1360 kg/ha obtained in S1 irrigation application, the second group was formed with the value in S2 (1645 kg/ha).

Uyanık Güngör et al. (2005) determined the drug leaf yield as 1766-5367 kg/ha. Avcı & Bayram (2013) found 7297 kg/ha, Ceylan et al. (1999) found it to be 7318 kg/ha in the first year and 7512 kg/ha in the second year. Katar & Gürbüz (2008), in the lemon balm (*Melissa officinalis* L.) plant, the drug leaf yield varied between 4779-6783 kg/ha in the first year and between 4938-7396 kg/ha in the second year and the highest values were obtained from 120 kg/ha nitrogen application. It was reported that the yield increased as the applied nitrogen dose increased. In our study, the drug leaf yield values obtained from both Tayşi 2002 and Ceylan 2002 cultivars were found to be lower than the results of other studies.

Essential oil rate (%)

The effects of different irrigation and nitrogen dose applications on the essential oil ratio of Tayşi 2002 cultivar are shown in Table 6.

As a result of the statistical analysis, it was seen that the application of different doses of irrigation in the first harvest of 2012 had a significant effect on the essential oil ratio at the level of 5%. Accordingly, the highest essential oil content (4.9%) was obtained in S2 irrigation application. This value formed the first group. Afterwards, a value of 4.4% was determined in S1 and S3 water applications, and the lowest rate (4.3%) was obtained in S4 application. These three values formed the second group. As the applied irrigation dose increased, the essential oil ratio decreased. When the values of the second harvest of the same year were examined, the trial factors did not have a statistically significant effect.

Table 6. The effects of different irrigation and nitrogen dose applications on the essential oil ratio of Tayşi 2002 cultivar (%)
Çizelge 6. *Tayşi 2002 çeşidinde farklı su ve azot dozu uygulamalarının uçucu yağ oranı üzerine etkileri (%)*

İrrigation	2012							2013						
	1.harvest			2.harvest			Annual Average	1.harvest			2.harvest			Annual Average
	Nitrogen (kg/ha)							Nitrogen (kg/ha)						
	0	80	X̄	0	80	X̄		0	80	X̄	0	80	X̄	
S1	4.4	4.3	**4.4b**	4.1	3.7	**3.9**	**4.2**	4.4b	4.7a	**4.5**	5.4	4.9	**5.1a**	**4.8**
S2	5.0	4.9	**4.9a**	4.2	3.9	**4.1**	**4.5**	4.7b	4.7a	**4.7**	5.1	4.2	**4.6bc**	**4.7**
S3	4.4	4.5	**4.4b**	3.9	3.9	**3.9**	**4.2**	4.7b	5.0a	**4.8**	4.8	4.7	**4.7b**	**4.8**
S4	4.4	4.3	**4.3b**	3.8	3.8	**3.8**	**4.1**	5.6a	4.8a	**5.2**	3.9	4.5	**4.2c**	**4.7**
Ort	**4.5**	**4.5**	**4.5**	**4.0**	**3.8**	**3.9**	**4.2**	**4.8**	**4.8**	**4.8**	**4.8**	**4.5**	**4.6**	**4.7**

OVERALL AVERAGE

İrrigation	2012			2013		
	Nitrogen (kg/ha)					
	0	80	X̄	0	80	X̄
S1	4.3	4.0	**4.2**	4.9	4.8	**4.9**
S2	4.6	4.4	**4.5**	4.9	4.5	**4.7**
S3	4.2	4.2	**4.2**	4.8	4.9	**4.9**
S4	4.1	4.1	**4.1**	4.8	4.7	**4.8**
Overall Average	**4.3**	**4.2**	**4.3**	**4.9**	**4.7**	**4.8**
LSD(1.hst)	İrrigation*:0.387			İrrigationxN*:0.560		
LSD(2.hst)	N.S.			İrrigation*:0.450		
LSD(Annual average)	N.S.			N.S.		

*: significant at the 5% level, N.S.:not statistically significant

When the table is examined, it could be stated that the irrigation xN interaction in the first harvest in 2013 affected the essential oil ratio at a statistically significant level (5%). It is seen that the highest essential oil ratio (5.6%) is in the S4xN0 combination. It formed the first group among other irrigation applications at N0 fertilizer level. This was followed by the combination of S3xN8 with 5% and S4xN8 with 4.8%. Irrigation applications at N8 fertilizer level formed a single group. The lowest rate (4.4%) was in the S1xN0 combination. When the values obtained in the second harvest in 2013 were subjected to statistical analysis, it was determined that the irrigation application was different at the level of 5%. The highest average essential oil ratio (5.1%) was obtained in S1 irrigation dose, followed by S3 irrigation application with 4.7% and S2 irrigation application with 4.6%. The values in S1 formed the first group, the values in S2 and S3 formed the second group, and the values in S3 and S4 formed the third group. The lowest rate was found in S4 irrigation application with 4.2%. It was determined that the amount of essential oil decreased as the applied irrigation dose increased.

When the general average essential oil ratios of both years were examined, it was seen that they were not affected by the trial factors at a statistically significant level.

The effects of different irrigation and nitrogen dose applications on the essential oil ratio of Ceylan 2002 cultivar are presented in Table 7.

When Table 7 is examined, it is seen that irrigation and nitrogen applications, which are test factors, did not have a statistically significant effect on 2013 essential oil ratios. Despite this, it is seen that irrigation application has different effects both in terms of annual general average values and in both harvests of 2012.

Table 7. Effects of different irrigation and nitrogen dose applications on the essential oil ratio of Ceylan 2002 variety (%).

Çizelge 7. *Ceylan 2002 çeşidinde farklı su ve azot dozu uygulamalarının uçucu yağ oranı üzerine etkileri (%).*

İrrigation	2012							2013						
	1.harvest			2.harvest			Annual Average	1.harvest			2.harvest			Annual Average
	Nitrogen (kg/ha)							Nitrogen (kg/ha)						
	0	80	X̄	0	80	X̄		0	80	X̄	0	80	X̄	
S1	4.3	3.6	**3.9b**	3.7	3.3	**3.5b**	**3.7**	4.5	4.2	**4.3**	5.6	5.6	**5.6**	**5.0**
S2	4.3	3.7	**4.0ab**	3.6	3.8	**3.7b**	**3.9**	4.6	4.4	**4.5**	6.0	5.8	**5.9**	**5.2**
S3	4.3	4.6	**4.4a**	3.7	3.8	**3.7b**	**4.1**	4.6	4.8	**4.7**	5.3	5.6	**5.4**	**5.1**
S4	4.0	3.8	**3.9b**	4.6	4.6	**4.6a**	**4.3**	4.6	4.5	**4.5**	5.4	5.6	**5.5**	**5.0**
X̄	**4.2**	**3.9**	**4.0**	**3.9**	**3.8**	**3.8**	**3.9**	**4.5**	**4.4**	**4.5**	**5.5**	**5.6**	**5.6**	**5.1**

OVERALL AVERAGE

İrrigation	2012			2013		
	Nitrogen (kg/ha)					
	0	80	X	0	80	X
S1	4.0	3.5	**3.8b**	5.1	4.9	**5.0**
S2	3.9	3.9	**3.9ab**	5.3	5.1	**5.2**
S3	4.0	4.2	**4.1ab**	5.0	5.2	**5.1**
S4	4.3	4.2	**4.3a**	5.0	5.1	**5.1**
Overall Average	**4.1**	**4.0**	**4.1**	**5.1**	**5.1**	**5.1**
LSD(1.hst)	İrrigation*:0.305			-		
LSD(2.hst)	İrrigation**:0.551			-		
LSD(Yıllık Ort)	İrrigation**:0.353			-		

*: significant at the 5% level, N.S.:not statistically significant

In the first harvest of 2012, the highest essential oil ratio was measured in S3 with 4.4%. This value was followed by the S2 application with 4% and they formed the first group. In the second group, it took place in S2 with 4% and S1 and S4 with 3.9%. In the second harvest, irrigation applications were found to be different, this time at the 1% level of importance. The highest essential oil content was measured in S4 irrigation application and this value (4.6%) formed the first statistical group. The other three values were in the second group. The lowest value was obtained from the S1 application with 3.5%. Here, it was observed that irrigation application increased the essential oil ratio.

If the average data of the second year of the trial (2012) are examined, the highest essential oil ratio was determined in S4 irrigation application with 4.3%, the lowest essential oil ratio was determined in S1 irrigation application with 3.7%.

Ceylan (1976) determined the essential oil ratio as 1.93-2.38 %, Uyanık Güngör et al. (2005), 4.7-5.7%, Avci & Bayram (2013) determined the average essential oil ratio as 2.58-4.00 % in Bornova location, 1.63-3.58 % in Dikili location. Bayram et al. (1998), in their study, stated that the essential oil rate varied between 2.36-3.11% in the first year and 1.74-2.45% in the second year. Bayram et al. (1998) reported that the average essential oil ratios in the plants they collected and grown from different locations were between 1.84-2.42% in the first year and between 2.06-4.82% in the second year. Ceylan et al. (1999) found the essential oil ratio to be 2.61-5.12%. For the diurnal variability research, Can et al. (2020) determined the essential oil ratio of İzmir thyme grown in Uşak to be 2.72% as the average of all

hours. Katar and Katar (2020) in their study in Eskişehir province, where they examined the relationship between ontogenetic variability and essential oil, reported that the highest essential oil rate was 3.60% during 50% flowering period.

In our study, the essential oil ratios of Tayşi 2002 cultivar were consistent with the data of Uyanık Güngör et al. (2005), Ceylan et al. (1999), Ceylan (1976), Avcı & Bayram (2013), Can et al. (2020), Katar & Katar (2020) and Bayram et al. (1998) was found to be higher than the data. The essential oil ratios in Ceylan 2002 cultivar were lower than Uyanık Güngör et al. (2005), Ceylan et al. (1999), and Ceylan (1976), Avcı & Bayram (2013) and Bayram et al. (1998).

CONCLUSIONS

In this study, which was carried out to determine the effects of different irrigation and nitrogen applications on yield and quality in two cultivars (Tayşi 2002, Ceylan 2002) of Oregano (*Origanum onites* L.), yield and quality criteria of both cultivars were determined differently according to irrigation practices. They gave responses, unaffected by nitrogen application alone.

As the amount of irrigation applied increased, drug herb yield, drug leaf yield increased in both cultivars, and the highest drug herb and drug leaf yield were determined in S3 and S4 applications. In terms of essential oil ratio, nitrogen application alone could not be effective in both varieties, but in general, the ratio of essential oil decreased as irrigation application increased. When the effects of trial factors on drug herb yield, drug leaf yield and essential oil ratio are evaluated in general, it is thought that it will be possible to obtain optimum yield and quality by applying fertilizer and irrigation every 20 days (with S3 irrigation application).

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