

EFFECT OF DIFFERENT HARVEST TIMES ON SOME YIELD AND ESSENTIAL OIL CHARACTERISTICS IN *Origanum onites* L.

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ABSTRACT

The purpose of this study was to determine the effects of different harvest times on some yield and quality characteristics in origanum cultivar “Ceylan-2002”. Field trial was conducted in 2014 and 2015 at Bornova/Izmir. Oregano plants were harvested starting on 15 of May (harvest time:1), 31 of May (harvest time:2), 16 of June (harvest time:3), 2 of July (harvest time:4), 18 of July (harvest time:5), 3 of August (harvest time:6), 19 of August (harvest time:7) and 4 of September (harvest time:8) and fresh herbage yield, drug herbage yield, drug leaf yield, essential oil content and essential oil yield in each of harvest time were determined. The result from the combined variance analysis over two years for each characteristic indicated that variation among means for harvest time was significant ($p \leq 0.01$) while differences between two years were not significant for all characteristics. The results showed that the highest drug herbage yield, drug leaf yield and essential oil yield were obtained at the 4th (15 of June) harvest time. It was concluded that the most suitable harvest time in coastal zone of Aegean region is 4th (2 of July) harvest time.

Keywords: drug herbage yield, drug leaf yield, essential oil content, harvest time, *Origanum onites* L.

INTRODUCTION

Several species of genus *Origanum* are native to the Mediterranean and Turkey is the biggest oregano supplier all around the world (Gungor et al., 2005). *Origanum onites* L., belongs to Lamiaceae family, is one of the most important species and distribute West and South parts of Turkey which is considered the genetic center of the genus *Origanum* (Ceylan et al., 2003). Although these regions are known as the main supplier of oregano in the world market (Gungor et al., 2005), collection of the plants from natural flora has led to serious problem in the trade of oregano. For that reason several agronomic studies have been performed in order to establish better cultivation techniques of oregano in field conditions (Ceylan et al., 1999; Sancaktaroglu and Bayram, 2011).

In some previous studies on oregano, plants have been mostly harvested at the beginning of flowering or during the flowering periods. (Otan and Sari, 1994; Ceylan et al., 1994; Arabaci, 1995; Ceylan et al., 1999; Putievsky et al., 1996; Gora et al., 2002; Baydar, 2002; Kirici and Inan, 2001; Bagdat, 2006; Karik et al., 2007 and Kizil et al., 2008). However, in some medicinal plant species, the plant was harvested at different stages of growth and development to determine the optimum harvest time in terms of yield and quality characteristics (Ozguven and

Tanisi, 1998; Gora et al., 2002; Badi et al., 2004; Toncer and Kizil, 2005; Kizil and Toncer, 2006; Telci and Hisil, 2008; Kizil et al., 2008; Kizil et al., 2009; Ramamneh, 2009; Toncer et al., 2010; Kizil et al., 2013; Zawislak and Wierdak, 2014). On the other hand, Otan and Sari (1994), pointed out that the harvesting at beginning of the flowering only in all samples of *Origanum onites* L. removed the ontogenetic variability. In addition, there has been the lack of knowledge about the effects of harvestings at budding period and beginning of seed setting on yield and quality characteristics in oregano. Therefore, at present study, it was aimed at estimation effects on some yield and quality characteristics of different harvest times and determination the most suitable harvest time in *Origanum onites* L. in Mediterranean region.

MATERIALS AND METHODS

Field study was carried out at the experimental area of Field Crops Department, Faculty of Agriculture, Ege University in Bornova/Izmir during 2014 and 2015 growing seasons in semiarid region. Izmir has a typical Mediterranean climatical conditions in the western Turkey. The highest temperature in the area was recorded as 28.3°C in August in the first year, and 28.0°C in July in the second year (Table 1).

Table 1. Temperature and precipitation data of the experimental area at Bornova in 2014-2015 (Anonymus, 2016)

	Mean Temperature (°C)			Total Precipitation (mm)		
	2014	2015	LYA	2014	2015	LYA
January	9.9	8.9	9.0	113.8	125.1	112.2
February	9.7	9.5	9.2	45.6	101.9	99.7
March	11.5	11.7	11.18	108.4	75.6	82.9
April	15.0	15.9	16.1	76.8	46.4	46.4
May	19.3	20.8	21.0	2.2	30.9	25.4
June	23.8	25.6	26.0	75.2	9.8	7.5
July	26.8	28.0	28.3	16.0	1.8	2.1
August	28.3	27.7	27.9	6.0	2.6	1.7
September	23	23.7	23.9	18.6	15.0	19.9
October	18.8	18.8	19.1	49.0	45.3	43.2
November	13.2	14.0	13.8	15.2	94.8	109.7
December	11.1	10.6	10.5	206.8	141.1	137.9
Mean-Total	17.5	17.9	18.1	753.6	690.3	688.6

LYA: Long year average

The total annual precipitation was 753.6 and 690.3 mm in 2014 and 2015, respectively. Experimental area is 31 m above sea level with mild Mediterranean climate condition. Average temperature and total precipitation are presented in Table 1. Soil texture of the experimental area was generally composed of clay (Table 2). The first 30 cm soil was clayey loam with pH of 7.61 and soil of 30-60 cm deep was clayey loam with pH of 7.64 in the experimental field (Ekren and Ilker, 2017).

Origanum onites L. cv. "Ceylan-2002" was used as plant material. The seedlings of *Origanum onites* L. cv. "Ceylan-2002" sown into a mixture of sand, manure and mulch (1:1:1) on November 15, 2011. The oregano seedlings were transferred to the experimental plots on

April 10, 2012. Each plot was arranged as three rows at a 0.2 x 0.4 m spacing. The field trial was conducted according to Randomized Complete Block Design (RCBD) with three replications. During the vegetation period the plots were uniformly irrigated and weeded when required. Although the first year was not harvested, it was harvested in the second year for stimulated to growing. Oregano plants were harvested done on 15 of May (harvest time:1), 31 of May (harvest time:2), 16 of June (harvest time:3), 2 of July (harvest time:4), 18 of July (harvest time:5), 3 of August (harvest time:6), 19 of August (harvest time:7) and 4 of September (harvest time:8) years in 2014 and 2015. Plants, after removing border effects were cut at a height of 10 cm above the soil surface and the following characteristics were measured:

Table 2. Some soil physical and chemical characteristics at the experimental field (Ekren and Ilker, 2017).

Depth (cm)	Texture	Total Soluble Salt (%)	Organic matter (%)	pH	CaCO ₃ (%)	Total N	Sand (%)	Silt (%)	Clay (%)
0-30	Clayey loam	0.074	2.82	7.61	23.98	0.129	28.6	39.40	32.00
30-60	Clayey loam	0.080	2.72	7.64	24.65	0.101	31.00	38.60	30.40

Fresh herbage yields (t ha⁻¹): The plants were harvested by hand with a saw knife, 10 cm above the surface, and immediately weighed for the obtained plot yields. Then the plot yield was converted to a yield for a hectare.

Drug herbage yields (t ha⁻¹): A sample of 500 g of green herb was taken from each plot. The samples were dried at 35 °C for 72 h to determine its dry weight.

Drug leaf yields (t ha⁻¹): A sample of 500 g green herbs was taken from each plot. The leaves and stems of the samples were separated by hand and weighed. The leaves were dried in an oven at 35 °C for 72 h to determine the dry weight.

Essential oil content (%): Dry leaf materials of 10 g were subjected to a 3 h water-distillation using a Neo-Clevenger apparatus, and the extracted essential oils were stored at 4 °C until the gas chromatography (GC) analysis.

The essential oil ratios of the plants were determined by a volumetric method (ml/100 g) (Wichtl, 1971).

Essential oil yields (I ha⁻¹): The essential oil yield of each plot was multiplied by drug leaf yield to determine essential oil yield.

The combined variance analysis was performed over two years for the values of all characteristics. All data were statistically analyzed using the TOTEMSTAT statistical program (Acikgoz et al., 2004). The treatment means were compared by using the LSD test as described by Steel and Torrie (1980). Mean over two years in characteristics where interaction of year x harvest time was non-significant were discussed.

RESULTS AND DISCUSSION

The result from the combined variance analysis over two years for each characteristic studied was presented in Table 3. The differences among means of harvest time

were significant ($p \leq 0.01$) while differences between two years were not significant for all characteristics. It was observed that the interaction of harvest time x year was significant for only essential oil content. Therefore, it can

be said that the means of harvest time do not vary much according to years in terms of properties except essential oil content. In other words, a consistent effect of harvest time occurred on these characteristics.

Table 3. Mean squares obtained from variance analyses combined over two years for all characteristics

Source	Degrees of freedom	Fresh Herbage Yield	Drug Herbage Yield	Drug Leaf Yield	Essential Oil Content	Essential Oil Yield
Block/Year	4	1.62	0.33	0.14	0.19	1575.59
Year	1	3.52 ^{ns}	0.32 ^{ns}	0.05 ^{ns}	0.21 ^{ns}	4070.45 ^{ns}
Harvest time	7	156.25**	33.63**	10.17**	0.71**	23175.54**
Year X Harvest time	7	6.79 ^{ns}	1.43 ^{ns}	0.40 ^{ns}	0.14**	806.74 ^{ns}
Error	28	13.34	2.79	0.91	0.04	1722.96

*: significant at the $p \leq 0.05$ probability level, **: significant at the $p \leq 0.01$ probability level, ns: not significant

The means of the years of 2014 and 2015 and also obtained over two years for fresh herbage yield in different harvest times were shown in Table 4. It was found that the year x harvest time interaction was not significant for fresh herbage yield. The mean of the highest fresh herbage yield was obtained from 4th harvest as 27.36 t ha⁻¹ while the mean of the lowest one value was found in the first harvest as 10.67 t ha⁻¹. The fresh herbage yield values for oregano had variations in several studies. The mean values of fresh herbage yields were reported as 10.45 t ha⁻¹ by Kirman (1993), 25.12 t ha⁻¹ by Ceylan et al. (1994) and 12.76 t ha⁻¹ by Ozsoy (1995). Ceylan et al. (1998) who studied on *Origanum onites* L. was recorded

mean of fresh herbage yield as 40.99 t ha⁻¹. Bayram et al. (1999) determined that fresh herbage yield of *Origanum onites* L. varied between 26.21 t ha⁻¹ and 45.34 t ha⁻¹. However, Avci (2006) who investigated yields and some quality characteristic of different 14 oregano clones found that the fresh herbage yields varied from 13.37 t ha⁻¹ to 37.33 t ha⁻¹ under Aegean ecological conditions. Our result for fresh herbage yield was higher than those obtained by Kirman (1993) and Ozsoy (1995) while being less than those Ceylan et al. (1998) and Bayram et al. (1999). On the other hand, these findings are in agreement with the results of Ceylan et al. (1994) and Avci (2006).

Table 4. Means of studied characters of cultivar Ceylan-2002 at harvest times.

Harvest Times	2014			2015			2014			2015			2014			2015		
	Fresh Herbage Yield (t ha ⁻¹)			Drug Herbage Yield (t ha ⁻¹)			Drug Leaf Yield (t ha ⁻¹)			Essential Oil Content (%)			Essential Oil Yield (l ha ⁻¹)					
1	10.79	10.54	10.67 ^d	4.33	4.47	4.40 ^d	2.63	2.71	2.67 ^{cd}	3.42 ^d	3.52 ^{cd}	3.47 ^d	68.64	95.39	82.01 ^d			
2	14.67	13.24	13.96 ^{cd}	6.52	5.75	6.14 ^{cd}	3.84	3.39	3.61 ^{cd}	4.47 ^a	4.52 ^a	4.49 ^a	155.51	152.90	154.20 ^c			
3	21.83	19.55	20.69 ^b	9.98	8.56	9.27 ^b	5.72	4.91	5.31 ^b	4.38 ^a	4.52 ^a	4.45 ^{ab}	228.94	221.57	225.25 ^{ab}			
4	27.15	27.56	27.36 ^a	12.34	12.22	12.28 ^a	7.05	6.98	7.02 ^a	3.75 ^{bcd}	4.58 ^a	4.17 ^{bc}	259.17	320.38	289.77 ^a			
5	21.91	22.66	22.28 ^{ab}	9.46	9.89	9.67 ^{ab}	5.21	5.44	5.32 ^b	4.52 ^a	4.42 ^a	4.47 ^{ab}	237.80	240.05	238.93 ^{ab}			
6	21.13	21.06	21.09 ^b	9.09	9.37	9.23 ^b	4.87	5.03	4.95 ^{bc}	4.28 ^{ab}	4.35 ^a	4.32 ^{abc}	208.51	219.12	213.81 ^{bc}			
7	17.08	20.87	18.97 ^{bc}	7.81	9.46	8.64 ^{bc}	3.82	4.63	4.23 ^{bc}	4.03 ^{abc}	4.18 ^{ab}	4.11 ^c	154.81	194.04	174.43 ^{bc}			
8	17.93	21.34	19.63 ^{bc}	8.19	9.29	8.74 ^{bc}	4.02	4.57	4.30 ^{bc}	4.53 ^a	4.37 ^a	4.45 ^{ab}	182.40	199.69	191.05 ^{bc}			
Mean	19.06	19.60	19.33	8.46	8.63	8.55	4.65	4.71	4.68	4.17	4.31	4.24	186.97	205.39	196.18			
LDS	Y:ns			Y:ns			Y:ns			Y:ns			Y:ns					
	HI: 5.84**			HI: 2.67**			HI: 1.53**			HI: 0.30**			HI: 66.41**					
	YxHI: ns			YxHI: ns			YxHI: ns			YxHI: 0.43**			YxHI: ns					

*: significant at the $p \leq 0.05$ probability level, **: significant at the $p \leq 0.01$ probability level, ns: not significant

The means of the years of 2014 and 2015 and also obtained over two years for drug herbage yield in different harvest times were shown in Table 4. It was found that the year x harvest time interaction was not significant for drug herbage yield. The highest drug herbage yield was recorded as 12.28 t ha⁻¹ at 4th harvest and also the smallest values was observed as 4.40 t ha⁻¹ at the 1st harvest. A wide variation appeared in results of various researchers about drug herbage yields. The mean of drug herbage yield was reported as 3.57 t ha⁻¹ by Kirman (1993). Ceylan et al. (1994) studied on *Origanum onites* L. and determined a mean value of 8.20 t ha⁻¹. In a study conducted under in Izmir ecological conditions, the mean of drug herbage yield was found to be 12.76 tons per hectare (Ceylan et al. 1999). Kirici and Inan (2001) reported that the highest drug herbage yield was 5.36 t ha⁻¹ in a Mediterranean

environment. However, Baydar (2002), recorded that the mean drug herbage yield of oregano was 2.30 t ha⁻¹ in Isparta location. Gungor (2002) reported that the drug herbage yield of oregano altered between 1.58 tons and 8.03 tons per hectare whereas Avci (2006) obtained that the drug herbage yields varied from 5.13 t ha⁻¹ to 11.29 t ha⁻¹. When the our result for drug herbage yields were compared with previous studies, the mean value in this study was higher than Kirman (1993); Ceylan et al. (1994); Kirici and Inan (2001); Baydar (2002) and Gungor (2002). Also, it is agreement with the findings of Ceylan et al. (1999) and Avci (2006).

The means of the years of 2014 and 2015 and also obtained over two years for drug leaf yield in different harvest times were shown in Table 4. The effect of year x

harvest time interaction on the drug leaf yield was not significant. The highest value was still obtained as 7.02 tons per hectare at 4th harvest and the lowest values were realized in first and second harvest times under Bornova ecological conditions as 2.67 and 3.61 tons per hectare, respectively. *Origanum onites* L.. In the various studies on *Origanum onites* L., different results varied from 2.57 to 8.65 tons per hectare were obtained (Kirman, 1993; Ceylan et al.,1994; Bayram et al., 1999; Ceylan et al., 1999 and Avci, 2006). But Gungor (2002) stated that these values ranged from 1.58 t ha⁻¹ to 8.03 t ha⁻¹. The mean values from our study were found to be higher than those of Kirman (1993) and Ceylan et al. (1994) while being compatible with Bayram et al. (1999); Ceylan et al. (1999); Gungor (2002) and Avci (2006).

The means of the years of 2014 and 2015 and also obtained over two years for essential oil content was presented in Table 4. This research showed that year x harvest time interaction was significant for essential oil content. This case pointed out that the mean values obtained from some harvest times had varied according to years. It was observed that the differences among means of 2nd, 3th, 5th and 8th harvest times were not significant and also they had the highest means of essential oil content over two years. Essential oil content (EO) of *Origanum onites* L. has been studied in many researches. This character could be affected by treatments, environmental condition and genetic factors. In the some previous studies on *Origanum onites* L., mean values varied from 2% to 6.12% were obtained (Kirman, 1993; Arabaci, 1995; Kirici and Inan, 2001; Ozel and Kaymaz, 2004 and Avci, 2006). The means in this study were higher than those of Kirman (1993); Ceylan et al. (1994); Arabaci (1995); Kirici and Inan (2001) while being in agreement with results of Ozel and Kaymaz (2004) and Avci (2006).

The means of the years of 2014 and 2015 and also obtained over two years for essential oil yields (EOY) in different harvest times were shown in Table 4. The year x harvest interaction was not significant for essential oil yield. The mean of highest essential oil yield was recorded as 289.77 l ha⁻¹ in full flowering period (4th harvest). However, the mean essential oil yield was lowest 1st harvest time. Although less essential oil content mean in 4th harvest time was realized than means of 2, 3, 5, 6 and 8th harvest times over two years, the highest essential oil yield was obtained in harvest time mentioned (4th) because its drug leaf yield was higher than those of others. Avci (2006), reported that EOY of *Origanum onites* L. was varied between 122.3 and 249.0 l ha⁻¹ in different *Origanum onites* L. clones collected from western Anatolia flora while Kizil et al. (2008), stated that EOY of oregano (*Origanum onites* L.) was varied between 119.3 l and 190.1 l per hectare in different development stages. The EOY mean in present study was higher than those of Baydar (2002); Kan et al. (2005) and Kizil et al. (2008) but it's in agreement with result of Avci (2006), when compared.

CONCLUSION

Based on the discussion of the results of this study the following conclusions could be drawn. It was found that the highest mean values were obtained at the time of 4th harvest (full flowering), and also the lowest mean values were observed at the time of 1st harvest (growth vegetation). The fact that year x harvest time interactions were not significant in all characteristics except the essential oil content, indicated that the differences among the means of harvest times did not change according to years. The drug leaf yield in oregano is a component of the drug herbage yield. Although in the 3rd and 5th harvest times the drug leaf yield means had significantly lower than that of 4th harvest time, because these two harvest times (3rd and 5th) had higher essential oil content, the mean values for essential oil yields were found to be included in the same statistical groups with 4th harvest time (225.25 and 238.93 l ha⁻¹, respectively).

As a result, it is observed that the most suitable harvest time in coastal zone of Aegean region is 4th (2 of July) harvest time. However, in case of possible delays in harvesting, it may be also harvested in 5th (18 of July) harvest time. In order to obtain the highest drug leaf and essential oil yields, the harvest seems possible in a period from the beginning of flowering to the end of flowering in Aegean region.

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