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DETERMINATION OF SOME YIELD AND QUALITY CHARACTERISTICS AMONG INDIVIDUAL PLANTS OF LAVENDER (*LAVANDULA ANGUSTIFOLIA* MILL.) POPULATIONS GROWN UNDER MEDITERRANEAN CONDITIONS IN TURKEY

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Abstract

This research was carried out on the individual plants of lavender (*Lavandula angustifolia* Mill.). In this research, the main aim was to find out the characteristics of the individual plants; to determine the existence of promising plants to continue the study under Mediterranean condition, and lastly to determine the genotypes which are able to supply the highest yield with better quality. In the study, the characteristics such as the plant height (cm), the flower height (cm), fresh plant yield (g/plant) and the essential oil rate (%) of 260 plants in the first year and 256 plants in the second year were measured. In the individual plants, the highest drug flower yields were 84.70 and 113.30 g/plant in first and second years of study respectively. The essential oil content varied between 0.07% and 4.58% in 2015, 0.05% and 3.55% in 2016 respectively. The results indicated that there was great variation among the individual plants in intrapopulation of *Lavandula angustifolia* Mill. The seeds of population as palnt material obtained from Pharmasaat GmbH (Germany). Thus the superior genotypes in terms of drug flower yield and essential oil contents can be used in plant breeding programs to develop useful variations for enhancing the oil yield.

Key words: Essential oil, Lavender, *Lavandula angustifolia*, Frequency distribution.

Introduction

There are three main lavender species which have high commercial values in the world. The lavender species which are called British lavender (*Lavandula angustifolia* Mill. = *L. officinalis* L. = *L. vera* DC) has higher essential oil quality whereas lavandin (*Lavandula intermedia* Emeric ex Loisel. = *L. hybrida* L.) which is called crossbreed, has higher essential oil yield and Spike lavender (*Lavandula spica* = *L. latifolia* Medik.).

Apart from these three types, there are some other types which are used for decorative purpose such as *L. dentata* (French lavender), *L. stoechas* L. (Spanish lavender), *L. latifolia* Medik. (Broad Leaf lavender), *L. multifida* (Fern leaf lavender), *L. canariensis* (Canarien Island lavender), *L. lanata* (Wollen lavender), *L. heterophylla* and *L.*× *allardii* (*L. dentata* × *L. latifolia* Medik.) (Tucker, 1985). Among these, only *L. stoechas* species of lavandula is exist in Turkish flora and it is called Karabas grass, locally (Baydar, 2013).

The lavender which is a member of Lamiaceae family is grown, especially, in the West Mediterranean Region. Lavender is one of the wild plants that are mostly grown in South France, Middle Italy, Spain and Greece. Lavender has a rooting depth about 80-100 cm downwards in accordance with the soil and climate conditions. The plant has plenty of side branches. The leaves are opposite to each other and are 2-6 cm long. Inflorescence is a terminal branched spike, 16-20 cm long. On the axis of spike, there are 4-6 bunches of flower. Each bunch of flower has 6-14 florets changing accordingly to some factors. The color of fruit ranges from dark brown to black. The weight of 1000 seeds is lower than 1 g (Ceylan, 1997). The lavender is cultivated in some countries such as Bulgaria, England, U.S.A. and North Africa (Ceylan, 1997). Mostly, the both of lavender (*L. angustifolia* Mill.) and lavandine (L. × intermedia Emeric ex Loisel.) species are cultivated in the worldwide, but only lavandine is cultivated as commercial species in Isparta/Turkey. Lavender has adapted under Turkey ecological conditions especially in drought and slope like fields during the several years (Baydar & Erbas, 2007; Baydar, 2010).

The essential oil of Lavender is generally used in cosmetics, perfumes, drugs and other industrial branches. It is antiseptic and also it is used in the field of aroma therapy due to its sedative effects like tranquilizer or insomnia-reliever (Ceylan, 1997; Baydar, 2007). The quality of lavender essential oil is especially evaluated according to the rate of linalyl acetate and linalool components. On other hands, the luteolin types of flavonoids in the content of the essential oil have bacteriostatic and spasmodic effects. Also, there are other minor components such as β-pinen, linalool, camphor, terpineol, borneol, and cineol in lavender essential oil (Baser, 1993). Verma *et al.*, (2010) was of the opinion that India was the best quality lavender oil producer when compared with the other countries such as Hungary, China and France. The lavender cultivation area has been increased in Turkey from 50 to 570 hectares since 2012 until 2017 (Anonymous, 2017).

The aim of this research is to determine some individual plants that are high yield and quality of *Lavandula angustifolia* Mill. under Izmir/Bornova in Turkey where is prevailing Mediterranean climate conditions for obtained superior types.

Material and Method

In this research, the *Lavandula angustifolia* Mill. population seeds were used, which were supplied from Pharmasaat GmbH (Germany) as research material. Lavender is an allogamous plants, so *Lavandula angustifolia* Mill. plants were propagated easily from vegetative cutting, field trials were carried out by the clonal selection method (Hoffman *et al.*, 1971). According to this method, first year plant population was generated and some plants with high yield and quality characters were selected among them during two years study. This research was first step of clonal selection method to obtain desired types. The seeds were sown on seedbeds on 24th December, 2012 and the grown seedlings were planted on the field 70 cm between row × 50 cm intra row on 27th March 2013. The experimental fields was fertilized with 50 kg N ha^{-1} (21% ammonium sulphate) and 50 kg P ha^{-1} (46% granulated triple superphosphate) fertilizers in each years. The trial was conducted on the trial area of Ege University, Faculty of Agriculture, in 2014-2015 and 2015-2016 cultivation seasons Izmir-Turkey.

Izmir, where the trial was carried out has a typical Mediterranean climate. The highest temperature in the area was recorded as 28.8 C° in August in the first year, and 26.9 C° in July in the second year. Experimental area was 31 m above sea level with mild Mediterranean climate condition. Average temperature and total precipitation are presented in Table 1.

In this research, 260 and 256 individual plants were harvested during first and second years respectively. The individual plants were harvested at blooming period between 1 June to 1 July and 26 May to 22 June in the first and second years, respectively. In the individual plants, the plants heights measured from the soil surface to the top level of the plant and inflorescence lengths were measured from the bottom to top of each inflorescence by ruler at blooming times. The plants were harvested manually about 10 cm under the flower. The harvested plants were dried at 35 C$^{\circ}$ in the drying boxes for 72 hours. After the drying process, flowers and stems were separated and weighed for obtained drug flower yield. Also, in this research, extraction of essential oil was carried out by weighting 10 g of drug flowers materials then were subjected to 3 hours water-distillation using Neo-Clevenger apparatus. The essential oil ratios of the plants were determined by the volumetric method (ml/100 g) (Wichtl, 1971).

Results

The highest, lowest and mean performances with CV values are presented on the Table 2. In measured characteristics, the high value of CV demonstrated that there were considerable variations among individual plants in intra-population of examined *L. angustifolia*. These extensive variations are quite advantageous for obtaining superior plants with plant selection methods in plant breeding programs. The plant height values in the second year were higher than the first years in the present study. The highest and the lowest plant height values were obtained 2.70 cm and 33.00 cm in the first year. Also, in the second year of study the plant height values were changed between 6.42 cm-57.00 cm. The mean plant height value was 19.00 cm in 2015 and 23.96 cm in 2016. *Lavandula angustifolia* Mill. is known as a perennial plant, for this reason, lavender plants are expected to develope in the second year. Therefore, the yield performances of the second year were higher than first year.

The flower height values were recorded between 0.70 and 7.00 cm in 2015 and 1.40-20.90cm in 2016. The highest flower height 20.90 cm was obtained in the second year (Table 3). Also, Frequency distribution of flower height shown that 76.84% of flower height values were changed between 1.40- 4.20 cm in first year and 97.01% of flower height values were less than 9.20 cm in second year of study.

The fresh flower yields means values of individual plants were 54.84 g in the first year and 83.26 g in the second year. The highest fresh flower yield of individual plant was obtained from the second year as 305.42 g. Furthermore, the results indicated that the fresh flower yields values in the second year were higher than the fresh flower yields values in first year. According to the results of frequency distribution analysis, the highest ratio of flower yield was obtained between 41.34 g and 59.36 g among 260 harvested plants in the first year.

Table 1. Trial years and long years mean temperature (°C) and total precipitation (mm) values of Bornova ecological conditions.

Claimate factors	Years	Months												Avrage
		Jan.	Feb.	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.	
Average temperature (°C)	2015	11.7	11.5	13.3	17.0	21.1	25.2	28.1	28.8	24.1	18.7	14.1	12.0	18.8
	2016	5.8	11.0	10.6	16.2	17.9	25.0	26.9	26.8	22.1	16.5	11.2	10.2	16.7
	Long years	8.1	8.7	10.9	15.1	20.3	25.4	27.9	27.2	22.9	18.0	13.0	9.9	17.3
														Total
Precipitation (mm)	2015	21.6	163.4	133.3	70.1	57.8	21.0	96.2	30.9	0.2	1.0	12.9	48.1	656.5
	2016	232.9	84.9	122.0	28.4	37.1	2.6	0.0	0.4	8.6	0.5	123.8	20.2	661.4
	Long years	112.2	99.7	82.9	46.4	25.4	7.5	2.1	1.7	19.9	43.2	109.7	137.9	688.6

Table 2. Maximum, minimum, mean and CV values of agronomic characteristics of *Lavandula angustifolia* Mill. individual plants.

	Plant height (cm)		Flower height (cm)		Fresh flower yield (g/plant)		Drug flower yield (g/plant)		Essential oil content (%)	
	Years		Years		Years		Years		Years	
	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
Maximum	33.00	57.00	7.00	20.90	185.50	305.42	84.70	113.30	4.58	3.55
Minimum	2.70	6.42	0.70	1.40	5.30	9.98	1.60	2.90	0.07	0.05
Mean	19.00	23.96	2.94	4.94	54.84	83.26	23.56	34.93	0.87	1.00
CV (%)	25.28	53.94	41.90	52.33	56.47	53.28	58.54	54.42	72.15	70.65

In this study, the drug flower yield values in the second year were higher than in the first year. The ranges of flower yield values were 1.60-84.70 g and 2.90-113.30 g in first and second years respectively. The results of essential oil contents manifested that the essential oil contents in first year (2015) were higher than the essential oil contents in second year. The highest essential oil contents were 4.58 % and 3.55% in first and second years respectively. The frequency distribution analysis indicated that 18.42% of individual plants of population had more than 1.42% essential oil content in first experimental year. Also, 20.30% of evaluated plants had more than 1.45% of essential oil content in second year.

In addition, in this study we have been able to recognize remarkable individual plants with high content of essential oil. These individual plants are very important in lavender breeding with selection method.

Discussion

Chrysargyris *et al.,* (2016b), published that plant height in lavender plants were changed between 19.26 and 22.27 cm/plant in different nitrogen doses while this parameters were varied from 18.49 to 22.95 cm/plant in various phosphorus levels. The comparision of the results of this study with the results of Chrysargyris *et al.,* (2016b), indicated that there were higher plant heights in both years of this study. In another study, Ceylan *et al.,* (1996) reported that the lavender plant height values varied between 20 and 60 cm. The results of the both years of this research were in accordance with Ceylan *et al.,* (1996) values. Arabaci and Bayram (2005) reported that the plant height values of lavender species between 43.7 and 69.5 cm. Also, Atalay (2008) mentioned the values between 46.1 and 59.8 cm while Kara & Baydar (2011), whose research was performed under the ecological conditions of Isparta (Turkey), stated that the plant height of lavandine type varieties (86.20 cm) have been higher than the lavender type varieties (63.20 cm). Karik *et al.,* (2017) carried out their study under the ecological conditions of Aegean and they found that the plant height of lavender type varieties were between 38.50-44.25 cm. We have demonstrated that even the plant height values could be affected by the environmental factors, the genetically potential of the varieties. Ceylan *et al.,* (1996) and Arabaci & Bayram (2005) confirmed that the plant height is evolving according to the varieties and environmental factors. In our study, the highest value of plant height was in accordance with Karik *et al.,* (2017). There are no reports on the yield and quality characteristics of lavender populations using individual plants nowadays.

In previous studies, the value of fresh flower yields was obtained between 5.57-14.99 ton ha^{-1} (Arabaci & Bayram 2005) and7.89-12.52 ton ha^{-1} (Ceylan *et al.,* 1997) under the Aegean ecological conditions of Turkey. However, considering to results of fresh flower yields could not be obtained from individual plants hence comparison with previous studies could not be performed.

Ceylan *et al.,* (1988) reported that the dry drug flower yield of the lavender varied between 1.02- 1.95 ton ha^{-1} and the mean value of the five years was 1.47 ton ha^{-1}. Arabaci & Ceylan (1990), found that the drug flower yield was 2.86 ton ha^{-1} and in continuation of Arabaci and Ceylan (1990)'s research, Ceylan *et al.,* (1996) found the mean values of drug flower yield 2.30 ton ha^{-1}, 2.86 ton ha^{-1} and 1.42 ton ha^{-1} for the second, third and fourth years of study under Bornova (Turkey) ecological conditions, respectively. Arabaci & Bayram (2005) found that the drug flower yield of lavender varied between 0.70-5.78 ton ha^{-1}, while Baydar & Erbas (2007) determined the mean dry drug flower yield of the variety Super Lavandine as 0.50 ton ha^{-1} under the ecological conditions of Turkey (Isparta). Kara (2011) obtained that the drug flower yield of lavender as 0.46- 1.46 ton ha^{-1} under ecological conditions of Turkey (Isparta). Atalay (2008) determined the drug flower yield of *L. angustifolia* as 0.64-1.13 ton ha^{-1} and Karik *et al.,* (2017) estimated the yield of the same species between 0.21- 0.62 ton ha^{-1} under Bornova ecological conditions. The researchers reported that the drug flower yield of the lavender affected by variety characteristics, harvest time, environmental factors, growing conditions, sowing density and cultivation techniques (Arabaci & Ceylan, 1990; Ceylan *et al*., 1996; Arabaci & Bayram, 2005; Salinas *et al*., 2007; Atalay, 2008; Karik *et al.,* 2017).

In the present study, the experiment design wasn't conducted according to replication base method in field trial, for this reason, the converting of obtained values from individual plants to per hectare are not confident. Due to the similar reason, the drug flower yield results were not able to compare with previous research results.

Table 3. The Frequency distribution belonging to the characteristics plant height (cm), spike height (cm), fresh herb yield (g/plant), dry flower yield (g/plant) and essential oil content (%) of *Lavandula angustifolia* Mill.

2015					2016		
Plant height (cm)							
Scale	**Range**	**Number**	**%**		**Range**	**Number**	**%**
1	2.70-5.73	5	1.95		6.42-11.48	78	18.46
2	5.73-8.76	0	0		11.48-16.54	42	16.15
3	8.76-11.79	1	0.39		16.54-21.59	53	20.39
4	11.79-14.82	30	11.72		21.59-26.65	34	13.08
5	14.82-17.85	71	27.73		26.65-31.71	6	2.31
6	17.85-20.88	69	26.95		31.71-36.77	14	5.39
7	20.88-23.91	43	16.80		36.77-41.83	25	9.62
8	23.91-26.94	21	8.20		41.83-46.88	23	8.85
9	26.94-29.97	6	2.34		46.88-51.94	10	3.85
10	29.97-33.00	10	3.91		51.94-57.00	5	1.92
Flower (spike) height (cm)							
Scale	**Range**	**Number**	**%**		**Range**	**Number**	**%**
1	0.00-0.70	0	0		1.40-3.35	54	21.09
2	0.70-1.40	17	6.56		3.35-5.30	127	49.61
3	1.40-2.10	54	20.85		5.30-7.25	48	18.75
4	2.10-2.80	68	26.26		7.25-9.20	20	7.81
5	2.80-3.50	49	18.92		9.20-11.15	1	0.39
6	3.50-4.20	28	10.81		11.15-13.10	0	0
7	4.20-4.90	21	8.11		13.10-15.05	1	0.391
8	4.90-5.60	12	4.63		15.05-17.00	2	0.781
9	5.60-6.30	7	2.70		17.00-18.95	2	0.781
10	6.30-7.00	3	1.16		18.95-20.90	1	0.391
Fresh flower yield (g/plant)							
Scale	**Range**	**Number**	**%**		**Range**	**Number**	**%**
1	5.30-23.32	33	12.69		9.98-39.52	26	10.16
2	23.32-41.34	60	23.08		39.52-69.07	83	32.42
3	41.34-59.36	72	27.69		69.07-98.61	75	29.30
4	59.36-77.38	41	15.77		98.61-128.16	31	12.11
5	77.38-95.40	28	10.77		128.16-157.70	23	8.98
6	95.40-113.42	15	5.77		157.70-187.24	11	4.30
7	113.42-131.44	5	1.92		187.24-216.79	4	1.56
8	131.44-149.46	3	1.15		216.79-246.33	1	0.391
9	149.46-167.48	0	0		246.33-275.88	1	0.391
10	167.48-185.50	3	1.15		275.88-305.42	1	0.391
Drug flower yield (g/plant)							
Scale	**Range**	**Number**	**%**		**Range**	**Number**	**%**
1	1.60-9.91	37	14.23		2.90-13.94	24	9.36
2	9.91-18.22	65	25.00		13.94-24.98	59	23.05
3	18.22-26.53	73	28.08		24.98-36.02	79	30.86
4	26.53-34.84	38	14.62		36.02-47.06	45	17.58
5	34.84-43.15	25	9.62		47.06-58.10	21	8.20
6	43.15-51.46	10	3.85		58.10-69.14	14	5.47
7	51.46-59.77	6	2.31		69.14-80.18	7	2.73
8	59.77-68.08	2	0.77		80.18-91.22	0	0
9	68.08-76.39	3	1.15		91.22-102.26	4	1.56
10	76.39-84.70	1	0.39		102.26-113.30	3	1.17
Essential oil content (%)							
Scale	**Range**	**Number**	**%**		**Range**	**Number**	**%**
1	0.07-0.52	93	35.77		0.05-0.40	46	17.97
2	0.52-0.97	84	32.31		0.40-0.75	79	30.86
3	0.97-1.42	35	13.46		0.75-1.10	41	16.02
4	1.42-1.87	29	11.15		1.10-1.45	38	14.84
5	1.87-2.33	12	4.62		1.45-1.80	16	6.25
6	2.33-2.78	4	1.54		1.80-2.15	16	6.25
7	2.78-3.23	2	0.77		2.15-2.50	6	2.34
8	3.23-3.68	0	0.00		2.50-2.85	5	1.95
9	3.68-4.13	0	0.00		2.85-3.20	6	2.34
10	4.13-4.580	1	0.36		3.20-3.55	3	1.17

The essential oil is one of the most important criteria of medicinal and aromatic plants quality. Therefore, the essential oil content was a remarkable attribute in this research. According to some previous researches, the essential oil content of lavender should be contain at least 1.50% (Wichtl, 1971; Wagner, 1980), 1.0%, (Ceylan, 1997) and 0.5-1.0% (Baytop, 1999) for pharmaceutical and commercial purposes. In addition, Chrysargyris *et al.,* (2016a), obtained 3.01-4.07% of lavender essential oils under different water stres conditions. Also, Nurzynska & Zawislak (2016), reported 3.2% of essential oil in flower of *L. angustifolia* L. species. Furtheremore, Zheljazkov *et al.,* (2013), in their study about the effect of distilation time on lavender essential oil yield and composition concluded that the maximum content of lavender essential oil was acquired in 180 minutes distilation time (6.83 wt/wt%). This amount of essential oil was more than the essential oil content in present study. Ceylan *et al.,* (1988) reported a range between 1.26-3.14% for the essential oil rate of *L. officinalis*. Renaud *et al.,* (2001) found that the dry flower bud of lavandin contained 7.1-9.9% of essential oil while lavender varieties have a rate of 2.8-5.0%. Baydar (2013) mentioned that the variety Super Lavandine grown in Isparta has an essential oil rate of 1.0-1.5% for the fresh flowers with the stem and it varies between 5-6% for the drug flowers. Kara and Baydar (2012) found the essential oil rate of lavandin (*L.x intermedia* var. Super) for the drug flower between 7.50-8.60% while Atalay (2008) reported that the essential oil rate of drug flowers were 2.1-2.6%. Also, Arabaci & Bayram (2005) observed that rate of essential oil percentage 1.54-2.34% for the same species. Kara (2011) observed that essential oil contents were 2.10-9.62 % and Karik *et al.,* (2017) determined between 1.32 and 3.10%.

It is stated by many researchers that the active ingredients of the medicinal and aromatic plants may change according to genotype (Marotti & Piccaglia, 1992; Munoz- Bertomeu *et al.,* 2007), growing methods (Atalay, 2008), ecological conditions, harvest time (Arabaci & Ceylan, 1990), parts of the plant (Aburjai *et al.,* 2005; Baydar and Erbas, 2007), distillation method (Marotti & Piccaglia, 1992) and drying methods (Pinto *et al.,* 2007).

Hassiotis *et al.,* (2014) mentioned that essential oil rate was changed between 2.19 and 4.45% while Dudaa *et al.,* (2015) obtained the values between 1-6%. Also, Chrysargyris *et al.,* (2016b) stated that essential oil of lavender varied from 0.71 to 1.14% among different fertilizer treatments. Another research was conducted by Kirimer *et al.,* (2017) who found that range of its values was 0.7% and 2.6% under Ankara ecological condition in middle of Turkey. Rasheda *et al.,* (2017) determined that essential oil content of lavender fluctuated between 0.61-0.81% in different extraction methods.

The results of present research were in accordance with the results of Hassiotis *et al.,* (2014), Dudaa *et al.,* (2015), Kirimer *et al.,* (2017) and Ceylan *et al.,* (1988); However in the results of Ceylan *et al.,* (1988), these values remained restricted only 2-4% of the populations. The essential oil rate values obtained in present study were higher than the results of some previous studies (Rasheda *et al.,* 2017; Chrysargyris *et al.,* 2016b).

Conclusion

The results of this study, demonstrated that there was much variation about investigated characteristics in the individual plants of lavender population. According to German Pharmacopoeia (DAP 8), essential oil of lavender drug flower should be more than 1.5%. Moreover, frequency distribution analysis results indicated that, approximately 18.44% and 20.30% of individual plants had more than 1.42% and 1.45 % essential oil values in first and second years of this study respectively. In additional, it can be said that there were high level diversity of drug flower yield among individual plant in evaluated population. Essential oil content and drug flower yield acceptable values are very important and considerable for obtaining superior types of lavender breeding. These individual plants can be used as benefit materials in future breeding program with selection for achieving the high performance and superior genotypes under Mediterranean ecological condition in Turkey.

References

Aburjai, T., M. Hudiab and V. Cavrini. 2005. Chemical composition of the essential oil from different aerial parts of lavender (*Lavandula coronopofolia* Poiert) (Lamiaceae) grown in Jordan. *J. Ess. Oil Res*., 17: 49-51.

Anonymous.2017. https://biruni.tuik.gov.tr/disticaretapp/disticaret.zul?param1=21&param2=4&sitcrev=0&isicrev=0&sayac=5802 (Accessed July, 2017)

Arabaci, O. and A. Ceylan. 1990. Researches on yield and ontogenetical variability of some perfume plants plants (*Lavandula angustifolia* Mill., *Melissa officinalis* L., *Salvia sclerea* L.). *Journ.E.U. Sci. Fac*., 1(1): 233-236.

Arabaci, O. and E. Bayram. 2005. Effect of plant density and nitrogen fertilizers on some agronomic and quality characteristics of lavander (*Lavandula angustifolia* Mill.) under the ecological conditions of Aydın. *ADU. J. Agr. Fac*., 2 (2): 13-19.

Atalay, A.T. 2008. Effects of different doses of some organic and inorganic nitrogen fertilizers on yield and quality of lavender (*L. angustifolia* Mill.) under the ecological conditions of Konya. Selçuk Uni. *Fac.Sci., Dept. Field Crops, MSc Thesis*, pp. 1-46.

Baser, K.H.C. 1993. Essential Oils of Anatolian Lamiaceae: A. Profile. *Acta Hort*., 333: 217-238.

Baydar, H and S. Erbas. 2007. Effects of harvest time and drying on essential oil properties in lavandin (*Lavandula x intermedia* Emeric ex Loisel.). I. International Medicinal and Aromatic Plants Conference on Culinary Herbs, 826:377-381.29 April - 4 May 2007, Antalya-Turkey.

Baydar, H. 2010. Lavander should go to Beyoglu from Isparta. *J. Agr. Actual.*, 15: 62-63.

Baydar, H. 2013. The science and technology of medicinal, aromatic plants and plants of pleasure (4. Ed.). *Suleyman Demirel Uni. Pub*., Isparta, pp. 244-248.

Baytop, T. 1999. Healing with plants in Turkey. (Past and present) Second edition, *Nobel Medical Publishing House*, Istanbul, 1-480 pp.

Ceylan, A. 1997. Medicinal Plants II (Essential oil plants). *E.U.J. Fac. Agri. Pub.* l. No: 481, pp: 306. Bornova/Izmir-Turkey.

Ceylan, A., A. Vomel., N. Kaya., N. Celik and E. Nigdeli.1988. Researches of plant density on yield and quality of Lavander (*Lavandula officinalis*). *E.U. J. Fac. Agri*., 25(2): 135-145.

Ceylan, A., E. Bayram and N. Ozay. 1996. Effects of different plant densities and nitrogen doses on some agronomic and technological characteristics of Lavander (*Lavandula angustifolia* Mill.). *Turk. J. Agri. & Forest*., 20: 567-572.

Chrysargyris, A., C. Panayiotou and N. Tzortzakis. 2016b. Nitrogen and phosphorus levels affected plant growth, essential oil composition and antioxidant status of lavender plant (*Lavandula angustifolia* Mill.). Ind. *Crops & Prod*., 83: 577-586.

Chrysargyris, A., Laoutari, S., Litskas, V.D., Stavrinides, M.C. and Tzortzakis, N. 2016a. Effects of water stress on lavender and sage biomass production, essential oil composition and biocidal properties against Tetranychusurticae (Koch). *Scientia Horticulturae*, 213: 96-103.

Dudaa, S.C., L.A. Marghitas, D. Dezmireana, M. Duda, R. Margaoan and O. Bobis. 2015. Changes in major bioactive compounds with antioxidant activity of *Agastache foeniculum, Lavandula angustifolia, Melissa officinalis* and *Nepeta cataria*: Effect of harvest time and plant species. *Ind*. *Crops & Prod*. 77: 499-507.

Hassiotis, C.N., F. Ntana, D.M. Lazari, S. Poulios and K.E. Vlachonasios.2014. Environmental and developmental factors affect essential oil production and quality of *Lavandula angustifolia* during flowering period. *Ind. Crops & Prod*. 62: 359-366.

Hoffman, W., A. Mudra and W. Plarre. 1971. Lehrbuch der züchtung Iandwirtschaflicher Kulturpflanzen. *Band I. Verlag Paul Parey. Berlin*.,51-53.

Kara, N and H. Baydar. 2012. Essential Oil Contents and Composition of Lavenders and Lavandins Cultivated in Turkey. *Res. on Crops*, 2012, 13(2): 675-681.

Kara, N. and H. Baydar. 2011. Essential oil characteristics of lavandins (*Lavandula x intermedia* Emeric ex Loisel.) of Isparta Province, Kuyucak District, where Lavender Production Center of Turkey. *Book of IX National Field Crops Congress (Bursa):* 1267-1272.

Karik, U., F. Cicek and O. Cınar. 2017. Determination of morphological, yield and quality characteristics of lavender (*Lavandula* spp.) species and varieties under Menemen ecological conditions. *ANADOLU, J. AARI*, 27 (1) 2017: 17-28.

Kirimer, N., S. Mokhtarzadeh, B. Demirci, F. Goger, K.M. Khawar and F. Demirci. 2017. Phytochemical profiling of volatile components of *Lavandula angustifolia* Miller propagated under in vitro conditions. *Ind. Crops & Prod*., 96: 120-125.

Marotti, M. and L. Piccaglia. 1992. Antibacterial and Antioxidant Properties of Mediterranean Aromatic Plants. *Ind. Crops & Prod*., 2: 47-50.

Munoz-Bertomeu, J.I. Arrillaga and J. Segura. 2007. Essential oil variation within and among natural populations of *Lavandula latifolia* and its relation to their ecological areas. *Biochem. Sys. & Eco.*, 35(8): 479-488.

Pinto, J.E.B.P., J.C.W. Cardoso, E.M. De Castro, S.K.V. Bertolucci, L.A. De Melo and S. Dousseau. 2007. Morphophysiological aspects and essential oil content in Brazilian-lavender as affected by shadowing. *Hort. Brasileira*, 25(2): 210-214.

Rasheda, M.M.A., Q. Tonga, A. Nagi, J.P. Li, N.U. Khane, L. Chena, A. Rotailf and A.M. Bakry. 2017. Isolation of essential oil from *Lavandula angustifolia* by using ultrasonic-microwave assisted method preceded by enzymolysis treatment, and assessment of its biological activities. *Ind. Crops & Prod*., 100: 236-245.

Renaud, E.N., C.D.J. Charles and J.E. Simon. 2001. Essential oil quantity and composition from 10 cultivars of organically grown lavender and lavandin. *J. Ess. Oil Res*., 13(4): 269-273.

Salinas, M.R., A. Zalacain, I. Blazquez and G.L. Alonso. 2007. Application of thermal desorption for the rapid differentiation of lavender (*Lavandula hybrida*) cultivars. *Agrochimica*, 51(1): 19-27.

Tucker, A.O. 1985. Lavander, spike, and lavandin. *The Herbarist*, 51: 44-50.

Verma R.S., L.U. Rahman, C.S. Chanotiya, R.K. Verma, A. Chauhan, A. Yadav, A. Singh and A.K. Yadav. 2010. Essential Oil Composition of *Lavandula angustifolia* Mill. Cultivated in The Mid Hills Of Uttarakhand, India, *J. Serbian Chem. Soc*., 75 (3): 343-348.

Wagner, H. 1980. Pharmazeutische Biologie 2. Drogen Undihra Inhaltshoffe, Gustav Fisher Verlag-Stuttgard, New York. 313(8): 735 pp.

Wichtl, M. 1971. Die Pharmakognostich Chemische Analys., Band 12, Frankfurt/M. p: 254.

Zheljazkovn, V.D., C.L. Cantrell, T. Astatkie and Jeliazkova. 2013. Distillation time effect on lavender essential oil yield and composition. *J. Oleo Sci*., 62(4): 195-199.

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