Asian Journal of Chemistry Vol. 21, No. 4 (2009), 3151-3160

Agronomic Properties and Essential Oil Composition of Basil Varieties of Landraces (*Ocimum basilicum* L.) in Turkey

OYA KAÇAR*, ERDINÇ GÖKSU and NEDIME AZKAN
Department of Field Crops, Faculty of Agriculture, Uludag University, Bursa, Turkey
Fax: (90)(224)4428836; Tel: (90)(224)2941523
E-mail: okacar@uludag.edu.tr

The objective of this study was to determine some agronomic properties, essential oil ratio and composition of some varieties and different sources of *Ocimum basilicum* L. landraces in Turkey. During 2002-2003, field trials were conducted at Uludag University, Faculty of Agriculture, Department of Field Crops, Bursa, in South Marmara region of Turkey. Four varieties and six landraces of *Ocimum basilicum* L. were included in the study. Field trials were arranged in the complete randomized block design with three replications. As a result of this research, it was determined that the highest values of plant height (46.3 cm), green herb yield (4386.4 kg ha^{-1}), drug herb yield (867.8 kg ha^{-1}), essential oil ratio (0.90 %) and essential oil yield (8.02 L ha^{-1}) were obtained from V-1. In addition, V-2 (0.88 %) and LR-5 (0.87 %) should be taken into consideration in terms of essential oil ratio. Taking into consideration of the chemical composition, it could be stated that the 'linalool' chemotype was found 80 % (V-1, V-2, V-3, V-4, LR-1, LR-3, LR-4 and LR-6), 'methyl eugenol/linalool' chemotype was found 10 % (LR-2) and 'methyl chavicol' chemotype was found 10 % (LR-5) of the investigated *Ocimum* landraces and varieties.

Key Words: Basil, *Ocimum basilicum* L., Drug herb yield, Essential oil ratio, Essential oil composition.

INTRODUCTION

The *Ocimum* genus belonging to the *Lamiaceae* family is characterized by a great variability both morphologically and chemotypically[1]. Basil, an aromatic plant, was originated in North West India, North-East Africa and Middle Asia[2]. There are many cultivars of basil which vary in their leaf size and colour (green to dark purple), flower colour (white, red, lavander, purple), growth characteristics (shape, height, flowering time) and aroma, making this plant an increasingly popular culinary and ornamental herb[3]. Primarily a cross pollinating species, many cultivars of basil easily intercross[4,5] and several species of *Ocimum* can form interspecific hybrids[6]. The taxonomy of *Ocimum* is complex due to interspecific hybridization and polyploidy of the species in the genus[7].

Among all the species, *Ocimum basilicum* L. (basil or sweet basil) has the most economic importance and is cultivated and utilized throughout the world[8]. *Ocimum* species are widely cultivated and extensively used as spice, perfume, cosmetics, insect repellent, medicine, in traditional rituals, as snuff and in food for their natural aroma and flavour[9-11]. Traditionally, basil has been utilized for its stomach pain, expectorant, diuretika, carminative and stimulant properties in folk medicine[12,13]. The oils of basil have been used principally in the food and cosmetic industries[14]. They have found wide application in perfumery, dental, oral products and confectionery products, sausages and baked goods[15,16]. The oil has antimicrobial[8,17] and antifungal activity[18]. Populations of *Ocimum basilicum* L existing in nature worldwide are examined in terms of agronomic characteristics and pharmacologic activities. The cultivation of the medical plant *O. basilicum* L. has become more important in recent years due to an increasing number of applications.

The purpose of the present work was to determine some agronomic properties, essential oil ratio and composition of some variety and different sources of *Ocimum basilicum* L. landraces in Turkey. This study will contribute to the knowledge of a local product that could improve the use of Turkish basil.

EXPERIMENTAL

The research was conducted in the experimental field of Uludag University, Faculty of Agriculture, Department of Field Crops, Bursa (40º 11' N, 29º 04' E), in South Marmara region of Turkey, in 2002 and 2003. The experimental field was located in the coastal area of northwestern Turkey, which is 70 m above the sea level. The soil is clay loam, slightly alkaline and rich in phosphorus and potassium containing 1.8 % organic matter. The weather conditions during the experimental period are presented in Table-1.

TABLE-1
TEMPERATURE, RAINFALL AND RELATIVE HUMIDITY VALUES OF LONG TERM PERIOD (1928-2002) AND INDIVIDUAL EXPERIMENTAL YEARS (2002, 2003)

Month	Mean temperature (ºC)			Rainfall (mm)			Relative humidity (%)		
	Long term (1928-2002)	2002	2003	Long term (1928-2002)	2002	2003	Long term (1928-2002)	2002	2003
May	17.8	17.3	18.8	50.0	50.5	45.7	69.2	67.9	67.7
June	22.1	23.0	23.8	30.4	25.2	2.4	61.1	62.1	54.8
July	24.5	26.7	25.3	24.0	49.9	-	58.8	64.4	64.4
August	24.1	24.6	25.6	18.9	31.1	-	60.4	65.2	65.2
October	20.1	20.8	19.2	40.1	67.2	66.9	65.8	70.3	70.3
September	15.6	15.8	16.6	60.4	119.3	125.1	72.1	75.2	75.2
Total	-	-	-	223.8	343.2	240.1	-	-	-
Mean	20.7	21.4	21.6	-	-	-	64.6	67.5	66.3

Plant material and growing conditions: Four varieties and 6 landraces of *Ocimum basilicum* L. were included in the study. Commercial seeds of varieties were purchased from a private company (Vilmorin) in Turkey. Six landraces of *Ocimum basilicum* L. were provided from Gazi Osmanpasa University, Agriculture Faculty, Field Crops Department, Herbs Garden. The seeds of 6 basil landraces were collected from local farms and home gardens in Turkey[7]. The 10 basil varieties and landraces used in this study are listed in Table-2, as well as the common, scientific names and some morphological characteristics of each one. For the transplanting of seedlings, the seeds were sown at the beginning of February in to a mixture of sand, manure and mulch (1:1:1) in greenhouse for every year. When basil seedlings reached 10 cm plant height, they were transformed to the field on May 22 for 2002, May 16 for 2003. Field trials were arranged in the complete randomized block design with 3 replications. Seedlings were planted in 30 cm × 25 cm distances. The plots were fertilized in both years with chicken manure (Organic Matter: 55.33 %, N:3 %, P_2O_5:3.73 %, K_2O:3.14 %, pH:6.58, Humidity: 12.2 %) before planting (4 kg ha^{-1}) and after every harvest (1 kg ha^{-1}). During the vegetation period, plots were irrigated whenever needed. Harvest was conducted manually by cutting the plants *ca.* 10 cm above soil surface. V-4 and LR-6 were harvested two times, other varieties

TABLE-2
COMMON AND SCIENTIFIC NAMES OF SOME MORPHOLOGICAL PROPERTIES OF THE BASIL VARIETIES AND LANDRACES

V&LR	Source	Common name	Scientific Name	Stem colour
V-1	Vilmorin	Sweet Basil	*O. basilicum* L.	Green
V-2	Vilmorin	Sweet Basil	*O. basilicum* L.	Purple
V-3	Vilmorin	Lettuce Basil	*O. basilicum* L.	Green
V-4	Vilmorin	Bush Basil	*O. basilicum* var. *minimum*	Green
LR-1	Tokat-Erbaa	Sweet Basil	*O. basilicum* L.	Green
LR-2	Tokat-T.çiftlik	Sweet Basil	O. *basilicum* L.	Green
LR-3	Malatya	Sweet Basil	O. *basilicum* L.	Green
LR-4	Erzurum	Sweet Basil	O. *basilicum* L.	Anthocyan
LR-5	Zonguldak	Sweet Basil	O. *basilicum* L.	Anthocyan
LR-6	Urfa	Bush Basil	O. *basilicum* var. *minimum*	Green
	Leaf colour	Leaf Size	Leaf Surface	Inflorescences colour
V-1	Green	Medium-Large	Plain	White
V-2	Dark Violet	Medium	Plain	Purplish and Pink
V-3	Green	Large	Undulate	White
V-4	Green	Small	Plain	White
LR-1	Pale green	Medium	Plain	White
LR-2	Pale green	Medium	Plain	White
LR-3	Anthocyan	Medium	Plain	Purplish and Pink
LR-4	Dark green	Medium	Plain	Purplish and Pink
LR-5	Green	Medium	Slight undulate	White
LR-6	Green	Small	Plain	White

V = Variety; LR = Landraces.

and landraces were harvested 4 times a year during vegetation period at the full flowering. Finally, harvested plants were air-dried in the shade at room temperature.

Extraction of essential oil: The isolation of the essential oils from the 20 g of dry leaves, flowers and stems (aerial parts) were done by hydrodistillation for *ca.* 2 h using modified clevenger-type apparatus. The essential oil rate was measured by the volumetric method[19] (v/w). The essential oils were stored in dark glass bottles at 4 ºC until analysis[8]. Essential oil content is expressed as percentage.

The components of these oils were determined by capillary gas liquid chromatography The GC analyses were carried out at the Central Laboratory of Ege University using a Carlo Erba Fractovap Series 2350 gas chromatograph equipped with a flame ionization detector. A glass column (3 m long, 3.18 mm internal diameter) packed with 3 % OV-1 50 chromosorb 80/100-mesh was used. Carrier gas N_2 at a flow rate of 25 mL/min. Each GC run lasted for 20 min. The oven temperature was isothermal at 110 ºC while the injector and detector temperatures were 225 and 250 ºC, respectively. Peaks obtained from GC runs were identified using the retention times obtained for reference standards (α-pinene, β-pinene, 1.8-cineole, linalool, camphor, methyl chavicol, geraniol, eugenol, methyl eugenol). Relative content (%) of individual constituents of the oil was proportionally calculated on the basis of the peak area corresponding to each component. All essential oil analyses were done in triplicate.

Statistical analyses: All data were subjected to analysis of variance for each character using MSTAT-C (version 2.1, Michigan State University, 1991) and MINITAB (University of Texas, Austin) software. The significance of basil varieties and landraces were determined at the 0.05 and 0.01 probability levels, by the F-test. The F- protected least significant difference (LSD) was calculated at the 0.05 probability level according to Steel and Torrie[20].

RESULTS AND DISCUSSION

The analysis of variance indicated that years significantly affected all the characters. It was determined that the first year had higher values than the second year statistically. According to the data combined over 2 years, differences among basil varieties and landraces were significant for all investigated characters (Table-3).

Agronomic characters

Plant height (cm): Plant height is an important morphologic and agronomic character for herbal plants. The first year plant height reached to higher level (39.6 cm) compared to the second year plant height (31.4 cm). Plant height of basil varieties and landraces varied from 23.8 (LR-6)-46.3 cm (V-1) (Table-3). In field trials conducted in Italy[8], Australia[15] and Turkey[21,22], plant height varied between 31.3-51.1 cm, 41-80 cm, 29.5-48.8 cm. Present results are in agreement with these previous studies.

Green and drug herb yield (kg ha^{-1}): Evaluating the green and drug herb yield, it was determined that the first year had higher values (3818.7 and 655.4 kg ha^{-1}) than the second year (2592.2 and 488.4 kg ha^{-1}), respectively. V-1 had the highest green and drug herb yield (4386.4 and 867.84 kg ha^{-1}) followed by V-4 (3716.5 and

TABLE-3
AVERAGE VALUES AND GROUPS WITH RESPECT TO SOME AGRONOMIC AND TECHNOLOGIC CHARACTERS IN COMBINED YEARS (2002-2003)

V&LR	Agronomic characters			Technologic characters	
	Plant height (cm)	Green herb yield (kg ha^{-1})	Drug herb yield (kg ha^{-1})	Essential oil ratio (%)	Essential oil yield (L ha^{-1})
V-1	46.3 a	4386.4 a	867.8 a	0.90 a	8.02 a
V-2	33.1 e	2595.5 e	376.4 g	0.88 a	3.33 c
V-3	25.0 f	2700.1 e	435.5 f	0.68 b	3.00 d
V-4	42.3 b	3716.5 b	777.1 b	0.41 f	2.89 de
LR-1	40.1 c	3144.1 d	533.7 e	0.49 e	2.60 e
LR-2	38.7 cd	3167.6 cd	551.6 de	0.50 e	2.77 de
LR-3	34.7 e	2658.1 e	427.7 f	0.62 c	2.64 e
LR-4	34.1 e	2610.9 e	446.1 f	0.57 d	2.28 f
LR-5	36.9 d	3345.6 c	571.6 d	0.87 a	4.94 b
LR-6	23.8 f	3729.3 b	731.8 c	0.51 e	3.60 c
LSD (0.05)	2.018**	178.7**	33.06**	0.03830**	0.3164**
YEAR					
2002	39.6 a	3818.7 a	655.4 a	0.61 a	4.04 a
2003	31.4 b	2592.2 b	488.4 b	0.67 b	3.17 b

Means of the same column followed by the same letters were not significantly different at 0.05 level using LSD test; V = variety; LR = Landraces.

777.1 kg ha^{-1}) and LR-6 (3729.3 and 731.8 kg ha^{-1}). The lowest green and drug herb yield was obtained from V-3 (2700.1 and 435.5 kg ha^{-1}), V-2 (2595.5 and 376.4 kg ha^{-1}), LR-4 (2610.9 and 446.1 kg ha^{-1}) and LR-3 (2658.1and 427.7 kg ha^{-1}) (Table-3). The relatively low yields obtained in 2003 may have been due to lower rainfall (240 mm) in this year than rainfall in 2002 (343.2 mm) (Table-1). Previous studies[15,21-24] under different ecological conditions with different basil genotypes and cultivars have shown that green herb yield varied from 448-5045.6 kg ha^{-1} and drug herb yield ranged from 188-1156.4 kg ha^{-1}. Besides, this disagreement may be due to the different varieties, lines and populations used in the experiments, different plant densities, harvest number and also different cultural applications.

Technologic characters

Essential oil ratio (%): It was determined that essential oil ratio was higher in the second year (0.67 %) than the first year (0.61 %). A wide range of essential oil ratio (0.41-0.90 %) was observed. The maximum essential oil ratio was obtained from V-1 (0.90 %), V-2 (0.88 %) and LR-5 (0.87 %) while the minimum value was recorded V-4 (0.41 %). Previous studies reported 0.3-1.5 % essential oil[3,7,21,22,24-27]. The formation of secondary metabolites that are typical of the plants depends on both genetic and environmental factors. Besides climatic conditions of the growing site, particularly edaphic factors also play an important role in variation of these secondary metabolites[8,28-30]. The essential oil ratio and its components also varied greatly depending on harvest periods and basil variety[3,32].

Essential oil yield (L ha^{-1}): The essential oil yield varied from 2.28 L ha^{-1} (LR-4)-8.02 L ha^{-1} (V-1). V-1 is at high levels both as a rate of drug herb yield and essential oil, which leads this variety (V-1) to be the most efficient. Although the rate of essential oil is high in V-2 and V-5, the low-efficient drug herb yield of them minifies the essential oil yield-efficiency to a great extent. In close agreement with previous studies[15,24] was determined.

Essential oil composition: *Ocimum basilicum* shows variation in morphology, chromosome numbers and essential oil composition and many different essential oil chemotypes have been described[33]. The genus *Ocimum* undergoes abundant cross-pollination resulting in large numbers of subspecies and varieties, which differ in essential oil composition and morphological characteristics. Therefore, the taxonomy of the group is diffucult[34]. There are many commercial basil varieties having different chemical properties[7]. Sheen *et al.*[35] stated that the plants of this species generally present a fresh, minty and sweet flavour with linalool, methyl chavicol and various sesquiterpenes being responsible for this.

The mean values and variation ranges of the essential oil composition in the basil varieties and landraces are listed in Table-4. Oxygenated monoterpenes were the major compounds in all chemotypes. Evaluating mean values of essential oil composition, the samples showed considerable variation in the content of linalool, methyl chavicol and methyl eugenol (Table-4). According to Grayer's chemotype classification system[33], the chemotypes for the 10 basil varieties and landraces utilized in this investigation were established and 3 main chemotypes and 5 subtypes were identified (Table-5).

Linalool chemotype: This chemotype was characterized by high linalool contents. Four varieties (V-1, V-2, V-3, V-4) and 4 landraces (LR-1, LR-3, LR-4, LR-6) belonged to this chemotype. V-2 (82.69 %), V-4 (81.73 %), LR-3 (80.39 %), LR-1 (78.34 %) and LR-4 (75.32 %) exhibited the 'linalool' chemotype with linalool as the most abundant component. Essential oil of LR-1 and LR-4 comprised of mostly linalool (more than 75 %) with little methyl eugenol. Therefore the linalool > methyl eugenol subtype were defined for these sample. Essential oil of V-1 and LR-6 contained more than 55 % linalool. V-1 presented three major components which defined the linalool > eugenol > 1.8-cineole subtype and LR-6 presented three major components which defined the linalool > methyl eugenol > eugenol subtype. Essential oil of V-3 contained more than 50 % linalool together with large amounts of methyl chavicol. V-3 presented two major components, linalool and methyl chavicol and the linalool > methyl chavicol subtype.

Linalool/methyl eugenol chemotype: Linalool/methyl eugenol chemotype was characterized by approximately equal proportions of methyl eugenol and linalool. Essential oil of LR-2 belonged to this chemotype. Methyl eugenol and linalool contents of LR-2 were 46.10 % (43.87 % in 2002, 48.33 % in 2003) and 45.63 % (49.23 % in 2002, 42.02 % in 2003), respectively. The major constituents, linalool and methyl eugenol, in LR-2 oil from plants grown in 2002 and 2003 were present

TABLE- 4
ESSENTIAL OIL COMPOSITION OF BASIL VARIETIES AND LANDRACES (%)

Compd.	Year	Concentration (%)									
		Varieties and Landraces									
		V-1	V-2	V-3	V-4	LR-1	LR-2	LR-3	LR-4	LR-5	LR-6
α-Pinene	2002	-	-	-	-	-	-	-	-	-	-
	2003	-	-	0.50	-	-	-	-	-	-	-
	Mean	-	-	0.50	-	-	-	-	-	-	-
β-Pinene	2002	1.22	0.93	0.68	-	-	-	0.29	0.23	0.73	0.75
	2003	1.64	1.31	1.00	-	0.49	-	0.38	-	1.03	-
	Mean	1.43	1.12	0.84	-	0.49	-	0.34	0.23	0.88	0.75
1.8-Cineole	2002	10.22	7.73	7.28	1.18	0.64	0.88	2.27	1.24	6.69	8.09
	2003	12.61	8.34	10.90	2.06	3.61	1.15	3.98	2.27	8.62	6.37
	Mean	11.42	8.04	9.09	1.62	2.13	1.02	3.13	1.76	7.66	7.23
Linalool	2002	65.10	83.65	59.02	81.35	83.37	49.23	81.69	67.16	30.07	52.89
	2003	66.13	81.72	52.23	82.10	73.31	42.02	79.09	83.47	34.17	61.30
	Mean	65.62	82.69	55.63	81.73	78.34	45.63	80.39	75.32	32.12	57.10
Camphor	2002	0.58	0.60	0.43	-	-	-	-	0.81	0.93	1.80
	2003	0.68	0.60	1.17	-	0.30	0.64	-	-	1.30	1.50
	Mean	0.63	0.60	0.80	-	0.30	0.64	-	0.81	1.12	1.65
Methyl chavicol	2002	1.72	1.68	24.03	4.70	0.90	0.99	3.77	2.40	55.54	1.56
	2003	1.30	1.05	23.63	1.54	2.26	1.57	6.18	0.76	48.35	1.74
	Mean	1.51	1.37	23.83	3.12	1.58	1.28	4.98	1.58	51.95	1.65
Geraniol	2002	1.49	0.93	-	3.77	1.14	-	0.50	0.97	1.64	2.79
	2003	1.42	1.05	1.11	2.23	-	-	0.86	-	0.76	4.43
	Mean	1.46	0.99	1.11	3.00	1.14	-	0.68	0.97	1.20	3.61
Eugenol	2002	13.78	2.63	3.12	4.07	-	1.81	7.87	4.43	3.87	12.24
	2003	11.43	3.12	2.14	7.22	5.05	2.37	7.20	8.77	3.52	9.10
	Mean	12.61	1.88	2.63	5.65	5.05	2.09	7.54	6.60	3.70	10.67
Methyl eugenol	2002	1.84	1.84	-	2.23	9.60	43.87	5.12	18.47	0.74	13.79
	2003	1.10	2.12	0.69	2.53	9.29	48.33	4.64	4.32	2.00	15.58
	Mean	1.47	1.98	0.69	2.38	9.45	46.10	4.88	11.40	1.37	14.69

TABLE-5
CHEMOTYPES OF 10 VARIETIES AND LANDRACES OF
Ocimum DETECTED IN TURKEY

V & LR	Common and scientific name	Chemotype	Subtype
V-1	Sweet Basil (*Ocimum basilicum* L.)	Linalool	Linalool > Eugenol > 1.8-Cineol
V-2	Sweet Basil (*Ocimum basilicum* L.)	Linalool	–
V-3	Lettuce Basil (*Ocimum basilicum* L.)	Linalool	Linalool > Methyl chavicol
V-4	Bush Basil (*Ocimum basilicum* var. *minimum* L.)	Linalool	–
LR-1	Sweet Basil (*Ocimum basilicum* L.)	Linalool	Linalool > Methyl eugenol
LR-2	Sweet Basil (*Ocimum basilicum* L.)	Methyl eugenol/ Linalool	–
LR-3	Sweet Basil (*Ocimum basilicum* L.)	Linalool	–
LR-4	Sweet Basil (*Ocimum basilicum* L.)	Linalool	Linalool > Methyl eugenol
LR-5	Sweet Basil (*Ocimum basilicum* L.)	Methyl chavicol	Methyl chavicol > Linalool
LR-6	Bush Basil(*Ocimum basilicum* var. *minimum* L.)	Linalool	Linalool > Methyl eugenol > Eugenol

in similar proportions (Table-4), indicating a resistance to weather-induced changes in composition. Although methyl eugenol is used commercially as a flowering and fragrance agent in food and perfume industries, there are concerns on its toxicity because of its structural resemblance of carcinogenic estragole and safrole[36].

Methyl chavicol chemotype: Methyl chavicol chemotype was characterized by high methyl chavicol contents. Essential oil of LR-5 contained more than 50 % methyl chavicol together with large amounts of linalool. The first main component of LR-5 was methyl chavicol (estragole) with 51.95 %. Linalool (32.12 %) was the other important component followed by % 1.8-cineole (7.66 %). LR-5 presented two major components, methyl chavicol and linalool and the methyl chavicol > linalool subtype were defined.

Basil has been classified according to the different geographical origins. The European chemotype, from Italy, France, Bulgaria, Egypt, Hungary and South Africa, is considered to have the finest flavour and has linalool and methyl chavicol as main components. The Exotic and Reunion chemotype from the Comoro Islands, Thailand, Madagascar, Vietnam and occasionally in the Seychelles is characterized by high concentrations of methyl chavicol. The Tropical and African chemotype from India, Guatemala and Pakistan is rich in methyl cinnamate[8,16] and a chemotype from North Africa and the former USSR is rich eugenol[37].

High contents of linalool in V-1, V-2, V-3, V-4, LR-1, LR-3, LR-4, LR-6 indicated that these varieties and landraces could be considered as European originated chemotypes. High contents of methyl chavicol with linalool in LR-5 could be considered as Exotic and Reunion chemotype with some influences of the European chemotype. Approximately equal proportions of linalool and methyl eugenol content (LR-2) is a mixture of European chemotype and methyl eugenol chemotype in the Turkish basils.

Many investigators have studied the chemical composition of the essential oil of basil and it has been found to be highly variable with linalool, methyl chavicol, eugenol and/or methyl cinnamate as the main constituents. On the basis of more than 200 analyses of oils extracted from *O. basilicum*, Lawrance[1] established 4 essential oil chemotypes (methyl chavicol, linalool, methyl eugeneol and methyl cinnamate) and also numerous subtypes[34]. Linalool has been reported as the major constituent of the essential oil of *O. basilicum* with 37.7-60.2 %[7] and 60.76-76.46 %[24] in Turkey, 67.84-70.37 % in Republic of Guinea[32], 41.56-49.48 in Japan[16], 41.17-76.20 % in Italy[8], 33.03 % in Colombia[34]. Methyl chavicol is a component commonly found in basil varieties[38]. Chemotypes with high methyl chavicol contents have been reported from Turkey[7] with 60.3-76.3 %, Australia[15] with 82.6-87.2 %, Japan[16] with 50.48-82.79 %.

The chemical composition of the essential oils, determined by genotype are mainly influenced by environmental conditions and agronomic techniques such as harvest times and harvesting methods, basil varieties, plant parts, developmental stage and method of extraction[3,8,14,31,39,40]. Furthermore, the variation in chemical composition of basil oils is thought to be due to polymorphism in *Ocimum basilicum* L., which is caused by interspecific hybridization. Apart from botanical characterization of the polymorphism, this species could be classified into distinct chemotypes, with many subtypes based on biosynthetic pathways of major compounds in the oils[1]. Moreover, Nacar and Tansi[41] reported that plant to plant variation among the same variety was, however great, which can be due to the fact that basil plants are easily cross pollinated if having opportunity. Seeds of the same origin are also reported to produce varying oil composition if cultivated under different conditions.

Consequently, the highest values were obtained from V-1, in terms of yield and essential oil ratio. It was concluded that V-1 could be successfully grown in Bursa ecological conditions. In addition, V-2 and LR-5 should be taken into consideration in terms of ratio of essential oils. Concerning the chemical composition of examined *Ocimum* landraces and varieties used in this study, it could be stated that the linalool, methyl eugenol/linalool and methyl chavicol chemotypes were found 80, 10 and 10 %, respectively.

REFERENCES

1. B.M. Lawrance, A Further Examination of the Variation of *Ocimum basilicum* L. in Flavors and Fragrances: A World Perspective; Proceedings of the 10th International Congress of Essential Oils, Flavors and Fragrances, Washington DC, USA, 1986, Elsevier Science Publisher B.V., Amsterdam, p. 161 (1988).
2. B.S. Gill and G.S. Randhawa, *Indian Perfumer*, **36**, 102 (1992).
3. M.R. Morales, D.J. Charles and J.E. Simon, in eds.: J. Janick and J.E. Simon, New Aromatic Lemon Basil Germplasm, New Crops, Wiley, New York, pp. 632-635 (1993).
4. R. Krishnan, *Indian Perfumer*, **23**, 74 (1981).
5. R.G. Nation, J. Janick and J.E. Simon, *Horticult. Sci.*, **27**, 1221 (1992).
6. S. Sobti and P. Pushpangadan, in eds.: C.K. Atal and B.M. Kapur, Studies in the genus *Ocimum*: Cytogenetics, Breeding and Production of New Strains of Economic Importance, Cultivation and Utilization of Aromatic Plants, Jammu-Tawi, India, pp. 457-472 (1982).
7. I. Telci, E. Bayram, G. Yilmaz and B. Avci, *Biochem. Systemat. Ecol.*, **34**, 489 (2006).
8. M. Marotti, R. Piccaglia and E. Giovanelli, *J. Agric. Food Chem.*, **44**, 3926 (1996).
9. H. Darrah, *Economic Botany*, **28**, 63 (1974).
10. J.C.T. Uphof, Dictionary of Economic Plants, New York, Verlag Von Vramer, p. 591 (1968).
11. U.P. de. Albuquerque, Taxonomia e etnobotanica do genero *Ocimum* L. (Lamiaceae) no Nordeste do Brasil-referencia especial para Pernambuco, Dissertaçao (Mestrado em Biologia Vegatal)-Centro de Ciencias Biologicas, Universidade Federal de Pernambuco., p. 125 (1996).
12. A. Ceylan, Tibbi Bitkiler II (Uçucu Yag Içerenler), E.Ü. Ziraat Fak. Yayinlari, No: 481, Bornova, Izmir, pp. 201-206 (1996).
13. T. Baytop, Therapy with Medicinal Plants in Turkey (Past and Present), Publication of The Istanbul University, No. 3255, edn. 1, p. 207 (1999) (In Turkish).
14. D.J. Charles and E.J. Simon, *J. Am. Soc. Horticult. Sci.*, **115**, 458 (1990).
15. K.J. Lachowicz, G.P. Jones, D.R. Briggs, F.E. Bienvenu, M.V. Palmer, V. Mishra and M.M. Hunter, *J. Agric. Food Chem.*, **45**, 2660 (1997).
16. Y. Hasegawa, K. Tajima, N. Toi and Y. Sugimura, *Flavour Fragrance J.*, **12**, 195 (1997).
17. G. Prasad, A. Kuman, A.K. Singh, A.K. Bhattacharya, K. Singh and V.D. Sharma, *Fitoterapia*, **57**, 429 (1986).
18. P.H.A. Zollo, L. Biyiti, F. Tchoumbougnang, C. Menut, G. Lamaty and P.H. Bouchet, *Flav. Fragr. J.*, **13**, 107 (1998).

19. M. Wichtl, Die Pharmakognostichchemische Analys. Band 12 Frankfurt/M (1971).
20. R.G.D. Steel and J.H. Torrie, Principles and Procedures of Statistics: A Biometrical Approach, McGraw-Hill Co., New York (1980).
21. E.O. Sarihan, A. Ipek, B. Gürbüz and N. Arslan, XV. Bitkisel Ilaç Hammaddeleri Toplantisi, pp. 305-310 (2004).
22. I. Telci, *J. Agric. Fac., Gazi Osmanpasa Univ.*, **22**, 77 (2005) (In Turkish).
23. S. Havla and L. Pukka, *J. Agric. Sci. Finland*, **59**, 11 (1987).
24. O. Arabaci and E. Bayram, *J. Agron.*, **3**, 255 (2004).
25. S. Tansi and S. Nacar, *Turk. J. Field Crops*, **4**, 71 (1999).
26. S. Tansi and S. Nacar, *Pak. J. Biolog. Sci.*, **3**, 395 (2000).
27. B. Gürbüz, A. Ipek, D. Basalma, E.O. Sarihan, C. Sancak and S. Özcan, *Asian J. Chem.*, **18**, 285 (2006).
28. CH. Franz, *Acta Horticulturae*, **132**, 203 (1983).
29. D. Palevitch, *Acta Horticulturae*, **208**, 29 (1987).
30. J.E. Simon, M.R. Morales, W.B. Phippen, R.F. Vieira and Z. Hao and Basil, in ed.: J. Janick, A Source of Aroma Compounds and a Popular Culinary and Ornamental Herb, Perspectives on New Crops and New Uses (ASHS pres, Alexandria, V.A) (1999).
31. M. Marotti, V. Dellacecca, R. Piccaglia and E. Giovanelli, *Acta Horticulturae*, **344**, 340 (1993).
32. S.-M. Keita, C. Vincent, J-P. Schmit and A. Belanger, *Flav. Fragr. J.*, **15**, 339 (2000).
33. R.J. Grayer, G.C. Kite, J. Goldstone, S. Bryan, A. Paton and E. Putievsky, *Phytochemistry*, **43**, 1041 (1996).
34. A. Vina and E. Murillo, *J. Braz. Chem. Soc.*, **14**, 744 (2003).
35. L.-Y. Sheen, Y.-H. Tsai Qu and S.-J. Tsai, *J. Agric. Food Chem.*, **39**, 939 (1991).
36. D. Phillips, IARC Scientific Publication, International Agency for Research on Cancer, Lyon, France, Vol. 125, pp. 131-140 (1994).
37. G. Vernin and J. Metzger, *Perfumer & Flavorist*, **9**, 71 (1984).
38. H.R. Juliani and J.E. Simon, in eds.: J. Janic and A. Whipkey, Antioxidant Activity of Basil, Trends in New Crops and New Uses, ASHS Pres, Alexandria, VA, pp. 575-579 (2002).
39. J. Boonardeaux, *J. Essent. Oil Res.*, **4**, 65 (1992).
40. R. Piccaglia, M. Marotti and G.C. Galletti, *J. Essential Oil Res.*, **3**, 147 (1991).
41. S. Nacar and S. Tansi, 28th International Symposium on Essential Oils, 1-3 September 1997, pp. 20-25 (1997).

(*Received*: 6 August 2008; *Accepted*: 23 January 2009) AJC-7170