ISSN : 1812-5379 (Print)
ISSN : 1812-5417 (Online)
http://ansijournals.com/ja

JOURNAL OF AGRONOMY

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Journal of Agronomy 4 (2): 96-102, 2005
ISSN 1812-5379

Variation of Yield, Essential Oil and Carvone Contents in Clones Selected from Carvone-scented Landraces of Turkish *Mentha* Species

[1]Isa Telci and [2]Nermin Sahbaz
[1]Department of Field Crops, Faculty of Agriculture, Gaziosmanpasa University, Tokat, 60240, Turkey
[2]Department of Technical Progress, College of High School in Milas, Mugla University, Mugla, Turkey

Abstract: In this study, carvone-scend clones of selected mint (*Mentha* sp.) from Turkey were studied for their yield, essential oil through field experiments in Randomized Block Design under semi-arid conditions in 1999 and 2000 in Central Anatolia of Turkey. Crops were harvested twice in the vegetation period of each year. Yield varied significantly and significant interactions occurred between year and clones. The greatest fresh herbage yield occurred for Clone 19 (*M. villoso-nervata*) in the first year and Clone 16 (*M. logifolia*) and Clone 8 (*M. spicata*) in the second year. Essential oil content for clones and for cutting periods varied significantly. Interaction between clones and cutting periods was significant. All clones, except Clone 25 (*M. spicata*) in first year, had high essential oil content in second cutting of both years due to the warmer periods. The greatest oil contents (3.77%) occurred for Clone 16 (*M. longifolia*). Carvone content ranged from 78.3 to 82.2% for Clone 12 (*M. spicata*), which yielded the greatest amount. Based on the results, the clones with high herbage yields and high essential oil and carvone contents are selected and used in the further variety improvements studies.

Key words: Carvone, essential oil, landraces, *Mentha spicata, M. longifolia, M. villoso-nervata*, spearmint, yields

INTRODUCTION

Essential oils extracted from odiferous plants are extensively used as flavoring in food and beverages and as fragrances in pharmaceutical and industrial products. Mint (*Mentha* sp.), belonging to *Labiatae*, is one of the most important sources of essential oil product[1]. *Mentha piperita* L., *M. spicata* L., *M. citrata* Ehrh and *M. arvensis* L. are major species of the genus cultivated for essential oils. Mint oils are mainly divided into two groups, peppermint and spearmint, according to their chemical components.

Spearmint oils are characterized by the presence of carvone, extracted mainly from *M. spicata* L. (syn: *Mentha viridis* L.) and some other *Mentha* species such as *M. longifolia* (L.) Huds. *M. villoso-nervata* Opiz[2,3] and *M. gracilis* Sole[4], etc. Carvone, which is an oxygenated monoterpenes, carries carminative properties and is used in the food and chewing industry.

Herb of spearmint is also consumed as herbal tea. The largest cultivation areas are in USA, Russia and China[5]. While it is widely consumed, cultivation area for industrial usage is very limited in Turkey. Although carvone scent mints are cultivated in limited areas in Turkey for spice and tea usage, this amount meets only little portion of the total demand. Therefore, considerable amount of mint oil is imported in Turkey. Research is needed agronomic and technological properties of mint landraces originated in Turkey.

Efforts have been made on the collection, characterization and conservation of different genetic resources in recent years. These collections serve as repositories of biodiversity for desired properties in plant improvement programs. Studies to improve alternative aromatic plants mainly consider characteristics such as wider adaptation, higher herbage, essential oil yield and better quality of essential oil[6]. Soil and climate conditions in most of the Turkish land are suitable for mind cultivation and yield and quality of the crop may be improved through cultivation studies[7]. However, currently only limited data are available on ideal cultivation techniques and superior cultivars.

Studies have focused on collecting and characterizing landraces of important medicinal plants under genetic erosions since 1997. Evaluation of the landraces and selection of suitable genotypes for subsequent plant breeding studies are under study[8]. Surveys on spearmint landraces targeted on providing data to be used in further plant improvement studies have been under study in Turkey. In this study, sources in the

Corresponding Author: Dr. Isa Telci, Department of Field Crops, Faculty of Agriculture, Gaziosmanpasa University, Tokat, 60240, Turkey Tel: +903562286110

plants are selected that serve as repositories of biodiversity for desired properties in plant improvement of those 25 of those surveyed carvone-scend clones of *Mentha* and assessed their yield, essential oil through field experiments under semi-arid conditions in 1999 and 2000 in central Anatolia of Turkey.

MATERIALS AND METHODS

Plant materials: Cuttings of spearmint landraces collected from different regions in Turkey were planted in the experimental plots on March 15, 1998 and evaluated for herbage yields and oil components during 1998. Of the previously surveyed Turkish landraces, 25 carvone-rich landraces were selected to be evaluated in the study (Table 1). Cuttings of clones were taken on August 15, 1998 and rooted in a medium, (1:1:1 washed sand, horse manure and field soil). Cuttings (clones) of single plant were taken from each of 25 carvone rich landraces, and were planted in the experimental fields plots.

Field experiment: The field studies were carried out during 1999 and 2000 at the experimental field at Gaziosmanpasa University, Tokat (40°13'-40°22' N, 36°10'-36°40' S and altitude 623 m), in Middle Black Sea region of Turkey. The climate is semi arid. Some climatic data for the area are given in Table 2. The soil was a clay loam with pH of 7.7, organic carbon of 1.70%, total nitrogen of 0.168%, available P (P_2O_5) of 11.6 kg ha^{-1} and available K (K_2O) 279.0 kg ha^{-1}. The experimental plots (4x2 = 8 m^2) were fertilized with 50 and 100 at N and P_2O_5 kg ha^{-1}, respectively in the late of September of 1998 and the plants were planted in Randomized Complete Block Design with three replications. The crops were harvested twice at flowering periods in both 1999 and 2000. The first harvests were in the early July and the second was in the late August. The total yields of clones were measured in both years.

Fresh herbage yield (in tones per hectare): Crops were harvested at the flowering stage, weighed in every plot and calculated as a cumulative total.

Dry-leaf yields (in tones per hectare): Fresh herbage samples (1 kg) (leaf +steam) were taken and dried at the 35°C in order to determine dry herbage content Dry-leaf content was determined by separating the leaves from stems in the dry herbage samples. Dry-leaf yield were measured using the content.

Samples of each clone from landraces were named botanically based on morphological properties, observed from the herbarium according to Davis[9], The herbariums have been kept at medicinal and aromatic plants herbarium in Faculty of Agriculture, Gaziosmanpasa University, Tokat, Turkey.

Table 1: Origin of the selected carvone-scent spearmint clones from Turkish landraces

Clone	Species	Origin	Clone	Species	Origin
1	*Longifolia*	Corum	14	*Spicata*	Nevsehir
2	*Spicata*	Samsun	15	*Longifolia*	Osmaniye
3	*Spicata*	Corum	16	*Longifolia*	Karaman
4	*Spicata*	Malatya	17	*Spicata*	Elazig
5	*Spicata*	Artvin	18	*Longifolia*	Elazig
6	*Spicata*	Afyon	19	*Villoso-nervata*	Sakarya
7	*Spicata*	Manisa	20	*Spicata*	Sakarya
8	*Spicata*	Tokat	21	*Spicata*	Sakarya
9	*Villoso-nervata*	Antalya	22	*Spicata*	Trabzon
10	*Spicata*	Tokat	23	*Longifolia*	Tokat
11	*Villoso-nervata*	Kilis	24	*Spicata*	Amasya
12	*Spicata*	Erzurum	25	*Spicata*	Ordu
13	*Spicata*	Corum			

Table 2: Weather during the experimental period

	Monthly rainfall (mm)		Mean daily temperature (°C)		Sunny time per day (h)	
Months	1999	2000	1999	2000	1999	2000
March	34	36	7.9	5.7	5.0	5.9
April	67	91	12.8	15.0	7.8	5.2
May	47	88	16.1	14.9	8.2	7.0
June	34	15	20.7	18.7	7.5	8.8
July	2	0	23.7	24.6	9.0	10.8
August	22	61	23.2	22.5	8.4	9.0
September	26	95	19.1	19.3	9.3	8.4

Distillation and analysis of carvone contents: Air-dry plant samples were subjected to hydro-distillation for 2 h in a modified Clevenger system (1:15 w v^{-1}). The essential oils were stored in glass bottles at 4°C until carvone analysis[10].

Carvone contents were determined with Carlo Erba gas chromatography equipped with FID. A glass column (3 mx18 mm) packed with 3% OV1 50 cromosorb 80/100 mesh was used. The carrier gas was N_2 with a flow rate of 25 mL min^{-1}; injection temperature was 230°C, detector temperature was 250°C and temperature programming was 60°C for 3 min, rising to 180 at 3°C min^{-1}. The component identification was based on comparison of their relative retention times with those of authentic standards.

Statistical analyses: Data for yields (fresh and dry leaf) from split plot design were analyzed with ANOVA. To determine effect of cutting periods, essential oil contents were analyzed with split-split plot design. Variables were grouped with Duncan's Multiple Range Test[11]. All statistical tests were performed with statistical software MSTAT-C (Michigan State University, 1991).

RESULTS AND DISCUSSION

Yields: Carvone scent spearmint clones were harvested twice for each year in a cropping cycle of two years. Fresh herbage yield and dry leaf yields were determined during the studies (Table 3). Mean results indicated that Clone 8

Table 3: Yields of the selected carvone scent spearmint clones selected from Turkish landraces

	Fresh herbage yield (t ha^{-1})				Dry leaf yield (t ha^{-1})		
	1999	2000^{+}	Mean*		1999	2000^{++}	Mean**
1	15.9o-s	30.3b-e	23.1c-f	1	2.4g-j	3.3a-I	2.8d-f
2	24.6d-m	24.9d-m	24.7b-e	2	3.4a-I	3.7a-f	3.5a-c
3	18.3m-s	28.0c-I	23.1c-f	3	3.0b-j	3.1b-j	3.0b-e
4	22.7f-o	32.1abc	27.4bc	4	3.4a-I	3.7a-f	3.5a-c
5	24.3d-n	22.8f-q	23.5c-f	5	3.4a-h	3.6a-g	3.5a-c
6	21.4h-p	19.2l-s	20.3e-g	6	2.7d-j	2.6e-j	2.6f-g
7	19.2l-r	23.2e-q	21.2e-g	7	2.6e-j	2.5f-j	2.5f-g
8	26.9g-k	36.4ab	31.7a	8	3.6a-f	3.6a-g	3.6ab
9	18.4m-s	20.4j-q	19.4gh	9	2.6e-j	3.0b-j	2.8d-f
10	20.4j-q	20.0k-r	20.2e-g	10	2.8d-j	3.0c-j	2.9ce
11	20.7i-q	29.0c-g	24.8b-e	11	3.3b-I	3.3a-I	3.3b-d
12	18.3m-s	25.4c-m	21.8e-g	12	2.7d-j	3.5a-h	3.1b-e
13	17.2n-s	29.5c-f	23.3c-f	13	2.6e-j	3.6a-h	3.1b-e
14	20.2k-q	25.8c-l	23.0c-f	14	2.9c-j	3.3a-I	3.1b-e
15	24.4d-n	22.8f-q	23.6c-f	15	3.3b-I	2.9c-j	3.1b-e
16	15.2p-s	37.9a	26.5b-d	16	2.5e-j	4.0a-d	3.2b-d
17	12.2s	13.0rs	12.6h	17	2.1ij	1.8j	1.9h
18	14.1q-s	14.9p-s	14.5h	18	2.3h-j	2.1ij	2.2gh
19	32.4a-c	27.6c-j	30.0a	19	4.1a-c	3.5a-h	3.8ab
20	24.4d-n	28.9c-g	26.6b-d	20	3.8a-e	4.3ab	4.0a
21	24.1d-n	32.2a-c	28.1ab	21	3.1b-j	4.6a	3.9a
22	24.0d-n	28.5c-h	26.2b-d	22	3.6a-h	4.1a-c	3.8ab
23	26.9c-k	30.9b-d	28.9ab	23	3.4a-h	3.1a-j	3.2b-d
24	21.5h-p	26.4c-l	23.9c-f	24	3.4a-I	3.5a-h	3.4bc
25	21.8g-p	22.5f-o	22.1d-f	25	2.6e-j	3.0c-j	2.8d-f
Mean^{a}	21.2b	26.1a		Mean	3.0	3.3	

$^{*}p<0.01$ (clones), ^{a} $p<0.05$ (year), $^{+}p<0.01$ (year x clone) $^{**}p<0.01$ (clones), $^{++}$ $p<0.01$ (year x clone)

(*M. spicata*), Clone 19 (*M. villoso-nervata*), Clone 23 (*M. longifolia*), Clone 21 (*M. spicata*) and Clone 4 (*M. spicata*) were better for fresh herbage yields. Mean fresh herbage yields of these clones were 31.7, 30.0, 28.9, 28.2 and 27.4 t ha^{-1}, respectively. Those values were greater or at least the same compared to those with 29 t ha^{-1} reported in the South Cukurova region[12] with 13.57 and 24.84 t ha^{-1} in the Ukraine[13], with 27.6 and 12.4 t ha^{-1} in the India[14] and (*M. piperita*) with 14.0 and 26.3 t ha^{-1} in Italy[15]. However, there are superior varieties in the other mint species such as *Mentha piperita*[12,16] and *M. arvensis*[17]. In spite of records on essential oil of *M. villoso-nervata*[3] and *M. longifolia*[3,18], there is no record available on the yields of *M. villoso nervata* and *M. longifolia* in literature. Herbage yields of the *M. villosa-nervata* clone (Clone 19) and *M. longifolia* clone (Clone 23) were agreed to yields from varieties of *M. spicata* from India[14] and Turkey[12]. Results revealed that the clones with fresh herbage yields were promising commercially for fresh consumption in the Middle Black Sea Region with mild temperate climate.

Climatic conditions during the vegetation period in 1999 were different from those in 2000. This had a significant impact on the results. The year 2000 was more suitable for mint growth due to higher rainfall (Table 2). Thus, mean fresh herbage yield of years was greater in 2000 (Table 3). From previous records[19], it is clear that a climate with adequate and regular rainfall during the crop growing is more suitable for mint species. Therefore it is believed that rainfall in April (92 mm), May (88 mm) and August (61 mm) in 2000 would be the reason for the high fresh herbage yields (Table 2). As a reported by Rumensika *et al.*[20], the slower growing performance of the crops during earlier periods in the first year would be another reason of lower yields in 1999. Cuttings in the first year caused clones to grow rapidly producing many new shots that started from the base of the plants. Greater leaf area indices resulted more radiant energy to be intercepted and consequently in more rapid growth of the spearmint clones in the second year[17]. However, some clones, especially Clone 19, had greater yield in the first year. The year x clone interactions was significant. The results further indicated that the clones had different growing performance in different years. While the greatest fresh herbage yields were obtained from Clone 19 with 32.4 t ha^{-1} in the 1999, it was obtained from Clone 37.9, 36.4, 32.2 and 32.1 t ha^{-1} from clone 16, clone, 8, clone 21 and clone 4, respectively.

Insufficient light and poor aeration conditions in dense canopy result in intensive vegetative growing in second year and it caused defoliation of lower leaves as pointed out by Kothari and Sing[4]. Thus, the differences between average leaf yields in years decreased and consequently were not significant. However, dry leaf yield showed a significant year x clone interactions as in fresh herbage yield. The highest dried leaf yields during the study were from Clone 21 (4.6 t ha^{-1}), Clone 20 (4.3 t ha^{-1}), Clone 22 (4.1 t ha^{-1}) and Clone 16 (4.0 t ha^{-1}) in the second year; and from Clone 19 (4.1 t ha^{-1}) in the first year. When mean results of both years are considered, 20, 21, 22, 19 and 8 Clone were better for dried leaf yields. Mean dry leaf yields of the clones were 4.0, 3.9, 3.8, 3.8 and 3.6 t ha^{-1} for 20, 21, 22, 19 and 8 Clone, respectively. Since leaf: stem ratio has a vital affection in dried leaf yield, contrary to fresh herbage yields, some clones with high fresh herbage yields such as Clone 23 had lower dried leaf yields. On the other hand, Clone 20 had higher leaf stem contents, which result in highest leaf yields. The results revealed that selected-carvone-rich spearmint clones from *M. spicata*, *M. longifolia* and *M. villoso-nervata* were suitable for cultivation compared to other *Mentha* species such as *M. piperita*[12,19] and *M. arvensis*[21].

Essential oil content: The value of spearmint product depends on the essential oil content and compositions of oils in leaves. Dry leaves of spearmint clones were subjected to hydro-distillation. The essential oil contents were significantly affected by both cutting times (Table 4). The changes in the oil content and composition depend on many factors such as genetic structure of plants[12,22,23], growing periods[15,24] and climatic conditions [25,26] Climatic variations occurred between cutting periods and genetic differentiations affected the accumulation of essential oil considerably. The response of the clones to essential oil was different in the climatic conditions. Essential oil contents in the first cutting ranged from 1.03 to 2.87% in the first year, and from 0.80 to 2.70 % in the second year (Table 4). However, increasing temperature and light intensity, as stressed by Kokkini *et al.*[3], in July and August (Table 2) increased oil contents in the second cutting of both years. Essential oil contents of the second cutting varied from 1.23 to 3.33% in the first year and from 1.63 to 3.77% in the second year (Table 4). Climatic differences in years (inter annual variations) had no significant effect on essential oil contents. However, double interactions of year x clone, cutting period x clone, year x cutting period and triple interactions of year x cutting period x clone were significant. Essential oil contents in all clones, except Clone 24 (*M. spicata)* and Clone 25 (*M. spicata)* in the first year, were higher in the second cutting. However, different values for essential oil content occurred in some clones such as Clone 1 (*M. longifolia)* that were affected significantly from changes in climate in the cutting periods. The essential oil

Table 4: Essential oil contents of the selected carvone scent spearmint clones selected from Turkish landraces

	1999		2000		
Clones	First cutting (%)	Second cutting (%)	First cutting (%)	Second cutting (%)	Mean[Clone] (%)
1	1.60g-s	2.83a-f	2.10d-r	3.53ab	2.52b
2	2.00e-s	2.60a-I	1.97e-s	2.50b-l	2.27bcd
2	1.97e-s	2.60a-I	2.57a-j	2.77a-g	2.47b
3	1.37j-s	2.80a-g	1.30l-s	2.20c-q	1.92c-g
5	2.00e-s	2.87a-e	2.10d-r	2.33b-o	2.33bc
6	1.33k-s	1.40i-s	1.10p-s	1.67e-s	1.38hi
7	1.20m-s	1.37j-s	1.07p-s	1.87e-s	1.38hi
8	1.83e-s	1.97e-s	1.97e-s	2.70a-h	2.12b-e
9	1.43i-s	1.87e-s	1.63f-s	1.93e-s	1.72e-I
10	1.20m-s	1.23m-s	1.27m-s	1.67e-s	1.34i
11	1.03qrs	1.50h-s	1.10p-s	1.87e-s	1.38hi
12	1.17n-s	1.63f-s	1.37j-s	1.77e-s	1.48f-I
13	1.17n-s	1.60g-s	1.07p-s	1.93e-s	1.44f-I
14	1.23m-s	2.00e-s	1.40i-s	2.23c-q	1.72e-I
15	1.53h-s	1.83e-s	1.80e-s	2.07e-r	1.81d-I
16	2.40b-m	3.33abc	2.70a-h	3.77a	3.05a
17	1.43i-s	2.07e-r	1.93e-s	2.07e-r	1.88c-h
18	1.03qrs	1.33k-s	1.43i-s	2.03e-r	1.46f-I
19	1.10p-s	1.83e-s	0.97rs	1.77e-s	1.42ghi
20	1.13o-s	1.70e-s	0.80s	1.63f-s	1.32i
21	2.13c-r	2.77a-g	2.23c-q	2.37b-n	2.38bc
22	2.13c-r	3.30a-d	2.10d-r	2.57a-j	2.53b
23	1.40i-s	2.20c-q	1.93e-s	2.27c-p	1.95c-f
24	2.87a-e	2.40b-m	2.20c-q	2.77a-g	2.56ab
25	2.37b-n	2.00e-s	2.00e-s	2.53b-k	2.22b-e
Mean(year x Cutting period)	1.60b	2.12a	1.68b	2.27a	
Mean years	1.86		1.97		

$p<0.01$ (all factors except int. $p<0.05$)

Table 5: Carvone contents of the selected carvone scent spearmint clones selected from Turkish landraces

	1999		2000		
Clones	First cutting (%)	Second cutting (%)	First cutting (%)	Second cutting (%)	Mean (%)
1	49.7	57.5	44.8	52.2	51.0
2	64.6	60.0	51.9	60.3	59.2
2	64.6	63.8	66.0	64.6	64.7
3	46.9	50.9	28.4	46.8	43.2
5	58.1	73.5	59.4	66.3	64.3
6	70.4	69.5	70.0	63.7	68.4
7	61.7	60.2	65.4	52.8	60.0
8	64.6	65.6	64.6	63.2	64.5
9	59.1	70.5	67.1	68.2	66.2
10	60.4	69.3	64.4	61.8	64.0
11	60.7	63.6	56.8	60.0	60.3
12	81.3	79.8	82.2	78.3	80.4
13	76.0	74.4	72.0	61.2	70.9
14	50.0	55.8	43.5	48.7	49.5
15	50.4	51.8	49.3	52.1	50.9
16	58.2	62.8	52.6	55.4	57.2
17	51.3	63.3	44.9	49.1	52.1
18	64.6	64.4	58.1	58.4	61.4
19	64.7	65.4	62.7	62.4	63.8
20	71.0	76.8	60.6	67.2	68.9
21	79.4	76.3	80.2	78.5	78.6
22	72.6	71.7	65.3	64.1	68.4
23	71.3	68.6	64.6	65.1	67.4
24	58.1	50.9	48.2	41.7	49.7
25	68.4	62.6	62.2	61.1	63.6
Mean cutting periods	63.1	65.2	59.4	60.1	
Mean years	64.1		59.7		

contents of Clone 1 originating from Corum was grouped in the first LSD group in second cutting of both years, however, it was classified in a lower LSD group in the first cuttings.

Unlike the rest, Clone 24 and Clone 25 had high essential oil contents in the first cutting of 1999. Its slow growth in the 1st year delayed harvest (1st harvest on July 15th and 2nd harvest on September 15th). Therefore, while the first cutting occurred in the mid summer second cutting occurred in the fall in the first year. Temperatures started to decline in second cutting, lowered essential oil contents in the clones.

The greatest oil content was obtained from Clone 16 (*M. longifolia*) in both years and cutting periods. The clone may be considered as high-oil types. Since Clone 1 (*M. longifolia*) yielded greater oil contents in the 2nd harvest, it may be recommended for warmer climatic conditions. Carvon rich *Mentha* species are known as spearmint oil, which are obtained from both native species of spearmint such as *M. spicata*, *M. longifolia, M. suaveolens, M. villoso nervata*[2,23,25,27] and cultured forms of *M. spicata*[5] and *M. x gentiles*[4]. We discovered in this study that some farmers in Turkey have been already cultivating *M. longifolia* and *M. villoso nervata* for spice consumption; therefore we included these clones into list (Table 4).

The essential oil contents of *Mentha* species are generally considered to be lower than 2%[28]. The oil contents over 2% may be attributed to their genetic potential that let accumulation of essential oils[25] and adaptation of mint crops for climatic conditions[24]. Higher oil contents of the studied species are also attributable to selection made by experienced native growers.

Carvone contents: The chromatographic analysis of hydro-distilled essential oils in selected-carvon-rich clones showed differences for carvone contents (Table 5). Although carvone contents of oils for different years and cutting time in some clones varied, the greatest carvon contents were obtained from Clone 12 (*M. spicata)* (82.2%) and Clone 21 (*M. spicata)* (80.2%). However, carvon contents of some clones were more sensitive to climatic variations during cutting periods and years than the others. For instance, while carvon contents of essential oils in Clone 5 (*M. spicata*) were not high in the first cutting of both years, they were quite high in the second cuttings. Clone 9 (*M. villoso nervata*) also showed similar variations in the first year.

Essential oil with 55-65% carvon contents is recommended for industrial use[29]. Many of essential oils in clones were suitable for industrial uses. The high carvone content found in this study agreed well to the values reported by Shimizu *et al.*[30] and Sacco *et al.*[31]. Kokkini *et al.*[3] also reported *M. villoso-nervata* with 80.1% carvone content from Greece.

Significant variations occurred among yield and quality properties of the clones. The results indicated that the clones had varying growing performance in different years. While the highest fresh herbage yields were obtained from Clone 19 in the first year, it was obtained from 16, 8, 21 and 4 Clone in the second year. The greater dry leaf yields were obtained from Clone 21. Results further showed that selected-carvone-rich spearmint clones from *M. spicata*, *M. longifolia* and *M. villoso-nervata* were proper to cultivate for commercial purposes compared to other cultivated *Mentha* spices. Essential oil of clones varied significantly. Clone 16 was selected as high oil types due to its greatest oil content. The Clone 12 and 21 had high carvone content. The clones with high herbage yields and high essential oil and carvone contents were selected for use in further variety improvement studies.

ACKNOWLEDGMENTS

This study summarized from a Ph.D Thesis of Isa Telci (supervised by Prof. Dr. Nermin Sahbaz, Aegean University, Turkey). We thank Gaziosmanpasa University for financial support (PN: 1999-06). We are also grateful to Dr. Gul TARICILAR (Uludag University, Turkey) for botanical identification of clones.

REFERENCES

1. Lawrence, B.M., 1993. A Planning Scheme to Evaluate New Aromatic Plants for the Flavor and Fragrance Industries. (Janick, J. and J.E. Simon, Eds.) New crops. Wiley, New York, pp: 620-627.
2. Kokkini, S., 1992. Essential Oils as Taxonomic Markers in *Mentha*. In: Advances in *Labiatae* Science (Harley, R.M. and T. Reynolds, Eds.), Royal Botanic Garden Rew, pp: 325-334.
3. Kokkini, S., R. Karousou and T. Lanaras, 1995. Essential oils of spearmint (Carvone-rich) plants from the Island of Crete (Greece). Biochem. Syst. Ecol., 23: 425-430.
4. Kothari, S.K. and U.B. Sing, 1995. The effect of row spacing and nitrogen fertilization on scotch spearmint (*Mentha gracilis* Sole). J. Essential Oil Res., 7: 287-297.
5. Maffei, M., A. Codignola and M. Fieschi, 1986. Essential oil from *Mentha spicata* (spearmint) cultivated in Italy. Flavour and Fragrance J., 1: 105-109.
6. Khanuja, S.P.S., A.K. Shasany, A. Srivastava and S. Kumar, 2000. Assessment of genetic relationship in *Mentha* species. Euphytica, 111: 121-125.
7. Ozel, A. and M. Ozguven, 2002. Effect of different planting times on essential oil components of different mint (*Mentha* spp.) varieties. Turk. J. Agric. For., 26: 289-294.
8. Telci, I.N. Incekara-Sahbaz, G. Yilmaz, and M.E. Tugay, 2004. Agronomical and chemical characterization of spearmint (M*entha spicata* l.) originated from Turkey. Econ. Bot., 54: 721-728.
9. Davis, P.H., 1982. Flora of Turkey and the East Aegean Islands, Vol. 7 Edinburg Univ. Press, 22 George Square, Edinburgh.
10. Marotti, M., R., Piccaglia and E. Giovanelli, 1996. Differences in essential oil composition of basil (*Ocimum basilicum* L.) Italian cultivars related to morphological characteristic. J. Agric. Food Chem., 44: 3926-3929.
11. Gomez, K.A. and A.A. Gomez, 1984. Statistical Procedures for Agricultural Research. John Wiley and Sons, Inc., New York.
12. Ozguven, M. and S. Kırıcı, 1999. Research on yield, essential oil, contents and components of Mint (*Mentha*) species in different ecologies. Turk. J. Agric. For., 23: 465-472.
13. Bugayenko, L.A., N. P Demchenko and L.G. Nazarenko, 1995. Effective methods of selection of essential oil crops. Flours, fragrances and essential oils. Proceedings of the 13th Intl Cong. Flavors, Fragrances and Essential Oils, Istanbul, Turkey, 5-19 October 1995. Vol: 2 1995, AREP Pub. Istanbul.
14. Singh, M., V.P. Singh, and D.V. Singh, 1995. Effect of planting time on growth, yield and quality of spearmint *(Mentha spicata* L.) Under subtropical climate of central Uttar Pradesh. J. Essential Oil Res., 7: 621-626.
15. Marotti, M., V. Dellacecca, R. Piccaglia and E. Giovanelli, 1993. Effect of harvesting stage on the yield and essential oil composition of peppermint (*Mentha piperita* L.) Acta Hortic., 344: 370-379,
16. Court, W.A., R.C. Roy, R. Pocs, A.F. More and P.H. White, 1993. Optimum nitrogen fertilizer rate for peppermint (*Mentha piperita* l.) J. Essential Oil Res., 5: 663-666.
17. Rao, B.R.R., 2002. Biomass yield, essential oil yield and essential oil composition of rose-scented geranium (*Pelargonium* species) as influenced by row spacing and intercropping with cornmint (*Mentha arvensis* L.f. *piperascens* Malinv. ex Holmes). Ind. Crops Prod., 16: 133-144.

18. Mimica-Dukic, N., O. Gasic, G. Kitc, L. Fellow and R. Jancic, 1991. A study of essential oil of *Mentha longifolia* growing in Yugoslavia. Planta Med., 57: 83-84.
19. Ceylan, A., 1987. Tıbbi Bitkiler II (uçucu yag icerenler). Ege Üniv. Ziraat Fak. Yayın No: 481, Bornova Izmir.
20. Ruminska, A., K. Suchorska and Z. Weglarz, 1984. Growth and development of peppermint (*Mentha piperita* L.) in the first and second year of cultivation. Ann. Warsaw Agril. Uni., SGGW-AR, Hortic., 12: 33-39.
21. Ozel, A., 1995. Harran Ovası Koşullarında Farklı Dikim Zamanlarının Bazı Nane (*Mentha* ssp.) Çeşitlerinde Verim ve Kalite Kriterlerine Etkisi, Ç. Ü. Fen Bilimleri Ens. Doktora Tezi, Adana.
22. Kokkini, S., 1991. Chemical races within the Genus *Menha* L. Modern Methods of Plant Analysis New Series (Linskens, H.F. and J.F. Jackson, Eds.), Springer-Verlag Berlin, Heidelberg, 12: 63-77.
23. Misra, L.N., B.R Tyagi and R.S. Thakur, 1989. Chemotypic variation in Indian Spearmint. Planta Med., 55: 575-576.
24. Sangwan, N.S., A.N.A. Farooqi, F. Sanabih and R.S. Sangwan, 2001. Regulation of essential oil production in plants. Plant Growth Regul., 34: 3-21.
25. Kokkini, S. and D. Vakou, 1989. *Mentha spicata* L. (*Lamiacea*) chymotypes growing wild in Greece. Econ. Bot., 43: 192-202.
26. Farooqi, A.H.A., N.S. Sangwan and R.S. Sangwan, 1999. Effect of different photoperiodic regimes on growth flowering and essential oil in *Mentha* species. Plant Growth Regul., 29: 181-187.
27. Kokkini, S. and V.P. Papageorgiou, 1987. Constituents of essential oils from *Mentha x Villoso-nervata* Opiz.growing wild in Greece. Flavour and Fragrance J., 2: 119-121.
28. Wagner, H., S. Bladt and E.M. Zaganiski, 1984. Plant Drug Analysis (A Thin Layer Chromatography Atlas) Springer-Werlag.
29. Tyler, V.E., L.R. Brady and J.E. Robbers, 1988. Pharmacognosy. Lea and Febiger Philadelphia.
30. Shimizu, S., N. Ikeda, H. Ueda and K. Hoshino, 1962. The essential oils of *Mentha japonica* Makino and its various hybrids (Studies on the essential oils of interspecific hybrids in the genus *Mentha* Part V.) Koryo, 67: 17-22.
31. Sacco, T., G. M. Nano and S. Scannerini, 1969. Sulla citotassonomia di mente selezionate della sezione spicatae. III. Numero cromosomico e catteri chemosistematici di due mente produtrici di carvone: *Mentha longifolia* (L.) Huds. Crispa Ten. *Mentha longifolia* (L.) Huds. var. Candicans Crantsz. Allionia, 15: 23-35.