Effects of Planting Density on Several Morphological and Yield Indicators of Two Sage (*Salvia officinalis* L) Ecotypes

Qatip Doda[a], Nikollaq Bardhi[b*], Foto Kashta[b], Dilaman Nelaj [c], Gjoshe Stefkov [d], Nefrus Çeliku [e]

[a] Regional Directorate of Agriculture, Dibër, Albania

[b] Agricultural University of Tirana, Faculty of Agriculture and Environment, Department of Plant Production, Kodër Kamëz, 1032, Tirana, Albania

[c] Regional Directorate of Agriculture, Kukës, Albania

[d] Institute of Pharmacognosy, Faculty of Farmacy, University "Ss. Cyril and Methodius" Skopje, Republic of Macedonia

[e] Ministry of Agriculture, Forestry and Water Economy, Republic of Macedonia

Corresponding author: Nikollaq Bardhi

Abstract

The study on the effects of planting density on several morphological and production indicators of sage (*Salvia officinalis* L.), was conducted during four consecutive years, 2010-2013, in Maqellara, Dibër, at the north-eastern part of Albania. A randomized complete block design (RCBD) with three planting distances (V1 = 60 cm x 30 cm, V2 = 60 cm x 25 cm, V3 = 60 cm x 20 cm), two ecotypes (a Dutch sage ecotype and a wild Albanian sage ecotype, grown in Dibra District, called Dibra's ecotype), and four replications for variant, with a plot size of 30 m^2 (or 330, 480 and 750 sage plants) for variant in each replication, was used. During the vegetative period and at the harvest, there were measured and evaluated several indicators at the flowering stage (at the harvest), such as number of shoots per plant, plants height (main shoot length) (cm), lateral shoot length (cm), mature leaf length (cm), leaf width (cm), and length of petiole (cm), content of the stalks in the herb (%), herb yield of the 1st and the 2nd cut, and total herb yield (q ha^{-1}). Obtained results showed that planting distances significantly affected the morphological and yield indicators of both sage ecotypes. The highest yearly and total herb yield was obtained using the planting distances of 60 cm x 25 cm (or 66000 sage plants ha^{-1}), with a four year mean yield of 21.7 q ha^{-1} and 22.5 q ha^{-1}, for Dutch sage ecotype and for Albanian sage ecotype, respectively. Recommended planting distances for both sage ecotypes grown in Maqellara, Dibër, climate conditions, is 60 cm x 25 cm.

KEYWORDS: ecotype, herb yield, indicator**,** morphological, planting density, sage, *Salvia officinalis* L.

INTRODUCTION

Sage (*Salvia officinalis* L.), also called common sage, garden sage, golden sage, kitchen sage, true sage, culinary sage, Dalmatian sage, and broadleaf sage, is a perennial, evergreen subshrub, with woody stems, grayish leaves, and blue to purplish flowers. Sage is one of the most used medicinal plants because of its culinary, environmental and human health values that it performs. It is a member of the family Lamiaceae and is native to the Mediterranean region and Central Europe, though it has naturalized in many places throughout the world (Lorraine, 2012; Stearn, 2004; Asllani, 2004; Baricevic *et al.*, 2002; Asllani, 2000). In Albania, it is a very sprout and very important medicinal plant, grown naturally as wild plant (ARIFP, 1988; Demiri, 1971; Paparisto *et al.*, 1988; Vangjeli *et al.*, 1995; Hyso and Çobaj, 2005) and as cultivated plant (Bardhi *et al.*, 2001; Ahmataj, 1996; Ahmataj and Çeku, 1988),

recently, with a high importance for the Albanian export and economy (Plaku *et al.*, 2014; WBA, 2002; Marko and Dishnica, 2002). Sage curative values are known since at the Antiquity, when for it was written a hymn: "O *Salvia* (sage), saviour of the advisory nature" (Bardhi, 2013). It has a long history of medicinal and culinary use, and in modern times as an ornamental garden plant. *Salvia officinalis* was described by Carl Linnaeus in 1753. It has been grown for centuries in the Old World for its food and healing properties, and was often described in old herbals for the many miraculous properties attributed to it (Papadhopulli, 1987; Ndoja, 2001). *Salvia officinalis* L cultivars are quite variable in size, leaf and flower colour, and foliage pattern, with many variegated leaf types (Bardhi, 2013; Haska *et al.*, 2005; Clebsch and Barner, 2003). *Salvia officinalis* has been used since ancient times for warding off evil, snakebites, increasing women's fertility, and more. Theophrastus wrote about two different sages, a wild undershrub he called *sphakos*, and a similar cultivated plant he called *elelisphakos*. Pliny the Elder said the latter plant was called *salvia* by the Romans, and used as a diuretic, a local anaesthetic for the skin, a styptic, and for other uses. Strabo described it in his poem *"Hortulus"* as having a sweet scent and being useful for many human ailments - he went back to the Greek root for the name and called it *lelifagus* (Kinziotis, 2000). The plant had a high reputation throughout the Middle Ages, with many sayings referring to its healing properties and value. It was sometimes called *Salvia salvatrix* (sage the saviour), and was one of the ingredients of Four Thieves Vinegar, a blend of herbs which was supposed to ward off the plague. Dioscorides, Pliny, and Gallen all recommended sage as a diuretic, homeostatic, emmenagogue, and tonic (Kinziotis, 2000). Common sage is grown in parts of Europe for distillation of an essential oil, though other species, such as *Salvia fruticosa* may also be harvested and distilled with it. It appears in many European cuisines, notably Italian, Balkan (Asllani, 2002) and Middle Eastern cookery. In British and American cooking, it is traditionally served as sage and onion stuffing, an accompaniment to roast turkey or chicken at Christmas or Thanksgiving Day. In the traditional Austrian medicine *Salvia officinalis* herb has been used internally (as tea or directly chewed) for treatment of disorders of the respiratory tract, mouth, gastrointestinal tract, and skin (Vogl *et al.*, 2013). *Salvia* and "sage" are derived from the Latin *salvere* (to save), referring to the healing properties long attributed to the various *Salvia* species (Kokalari *et al.*, 2007; Kinziotis, 2000). It has been recommended at one time or another for virtually every ailment by various herbals. Modern evidence shows possible uses as an anti-sweating agent, antibiotic, antifungal, astringent, antispasmosdic, estrogenic, hypoglycemic, and, and tonic. The strongest active constituents of sage are within its essential oil, which contains cineole, borneol, and thujone. Sage leaf contains 32 very important chemical ingredients, such as tannic acid, oleic acid, ursonic acid, ursolic acid, cornsole, corsolic acid, fumaric acid, chlorogenic acid, caffeic acid, niacin, nicotinamide, flavones, flavonoid glycosides, and estrogenic substances (Bardhi 2008; Haska *et al.*, 2005; Radanović *et al*., 2000). Investigations have taken place into using sage as a treatment for hyperlipidaemia and Alzheimer's disease patients (Akhondzadeh *et al.*, 2003; Dos Santos-Neto *et al.*, 2006; Perry *et al.*, 2007).

Sage is being a very important medicinal plant in Albania, which is going to occupy a huge cultivation area in the recent coming years, especially in hilly and mountainous areas (Kutrolli, 2010; Gjoni, 2009; Bardhi *et al*., 2001). Because of the worldwide growing market demands for its products (herbage and essential oils), there is a need of the increase of sage production, using natural sources, as well as through cultivation, maintaining its natural physical, chemical and biochemical characteristics.

Each country has to find the most appropriate cultivation technology in specific areas of the country. Several authors in different countries have shown that the plant growth, number of shoots per plant, flower and total herbage mass, essential oil content and composition, etc, depend on cultivation technology practices (Kumar *et al.*, 2013; Radanović *et al.*, 2000; Piccaglia *et al.*, 1997). Seedling production techniques, limestone soil treatment (Doda *et al.*, 2014), shading and planting density (Kumar *et al.*, 2013), root or foliar fertilization (Geneva *et al.*, 2010), significantly affected the herbage yield, essential oil content and composition, and other sage production indicators. Determination of the most appropriate planting density constitutes a key factor of the cultivation technology. The aim of the study was to find the most appropriate planting density for the wild Albanian sage ecotype and Dutch ecotype under Maqellara, Dibër, climate conditions.

MATERIAL AND METHODS

Experimental design. The study on the "Effects of planting density on several morphological and yield indicators of two sage (*Salvia officinalis* L) ecotypes", was conducted during four consecutive years, 2010-2013, in a land under the ownership of Qatip Doda, in Maqellara, Dibër, at the north-eastern part of Albania. A randomized complete block design (RCBD) with three different planting densities [V1 = 60 cm x 30 cm (5.5 sage plants per m^2), V2 = 60 cm x 25 cm (6.6 sage plants per m^2), and V3 = 60 cm x 20 cm (8.3 sage plants per m^2]; two ecotypes, a Dutch sage ecotype and a wild Albanian sage ecotype, grown in Dibra District, called Dibra's ecotype; and four replications, with a plot size of 30 m^2 (10 m x 3 m) or 330, 480 and 750 sage plants for variant in each replication, was used (Table 1).

Table 1. Experimental data design for one replication

Sage ecotype	Planting distances (cm)	Variants	Number of rows variant^{-1}	Number of plants row^{-1}	Number of plants variant^{-1}	Number of plants ha^{-1}
Dutch ecotype	60 x 30	V1	10	33	330	55 000
	60 x 25	V2	12	40	480	66 000
	60 x 20	V3	15	50	750	83 000
Albanian (Dibra's) ecotype	60 x 30	V1	10	33	330	55 000
	60 x 25	V2	12	40	480	66 000
	60 x 20	V3	15	50	750	83 000

The plot was situated in a hilly land with a sloping gradient of 10-15%. The total experiment size was 960 m^2. The experimental plot was surrounded from a protection area of 1.2 m, planted with sage as well.

Plant material. For planting, there were used prepared seedlings from a Dutch sage ecotype and an Albanian sage ecotype, grown naturally in Dibra District, called Dibra's sage ecotype. Seedlings' planting was carried out on 5th April 2010. First year was applied only one mowing, while during the other three consecutive years, there were applied two mowing, at the full blooming stage. During the first year there was applied one cut, on September 10, 2010, while during the other consecutive years, there were applied two cuts, at the full flowering stage, corresponding on June 5-15 and September 5-15, each year.

Measurements and observations. At the both harvest times (June and September of each year of the study), there were measured, counted and evaluated mean values for

several morphological and yield indicators, such as: plants height (main shoot length) (cm), number of shoots per plant, lateral shoot length (cm), mature leaf length (cm), mature leaf width (cm), mature length of petiole (cm), content of the stalks in the herb (%), and herb yield of the 1st cut and 2nd cut, and the total herb yield (q ha^{-1}).
Measurements for plant height, leaf length, leaf width and petiole, and counting for the number of shoots per plant and the number of leaves per shoot, were carried out in a representative sample of 10 sage plants for each variant on each replication, which were labelled with unmoved plastic labels during the study period. Measured data were recorded, analyzed and were calculated yearly and overall mean values.
Statistical analyses. The obtained data were subject of ANOVA: Two-Factor Without Replication (0.05 and 0.01) (Papakroni, 2001).

RESULTS AND DISCUSSION

Effect of planting distances on morphological (vegetative) indicators of two sage ecotypes: Dutch and Dibra's ecotype. The obtained data showed that the use of different planting densities significantly affected the main morphological indicators of both sage ecotypes. Behavior of both ecotypes followed almost the same pattern during cultivation, but the Albanian wild sage ecotype seems to be more vigorous and more productive than the Dutch ecotype.
Plants height *(main shoot length)* ***(cm)*** was measured in 10 sage plants for each variant in each replication. The obtained data showed that planting density significantly affected the main shoot length of both sage ecotypes at the harvest (flowering stage) since the first year. Observed results showed a significant raise during the second and the third year of cultivation for all variants and a significant decrease for the fourth year. The highest mean value of plants height (cm) was measured for the largest planting distances (60 cm x 30 cm) during the third year (93.25 cm), and the four years mean of plants height, as well (87.5 cm). Obtained data were significantly different for planting distances and years, for both probability levels (95% and 99%) (Table 2).

Table 2. Plants height (cm) of two *Salvia officinalis* L ecotypes (Dutch and Albanian ecotypes), according to different planting densities and different years of cultivation (mean values) (** significant at $p \leq 0.01$ and * significant at $p \leq 0.05$).

Sage ecotype	Variants	2010	2011	2012	2013	Mean
Dutch ecotype	60 cm x 30 cm	73.5	76.5	83.75	70.25	76.0**
	60 cm x 25 cm	79	79.7	88.5	70.25	79.4**
	60 cm x 20 cm	84.25	83.25	92.5	74.5	83.6**
	$F_{accounted}$	F_{crit}*	F_{crit}**			
Planting distances	41.167	4.459	8.649			
Years	58.467	3.838	7.006			
Albanian (Dibra's) ecotype	60 cm x 30 cm	80.75	81.25	83.25	75	80.1**
	60 cm x 25 cm	84.75	85.75	89.25	73.75	83.4**
	60 cm x 20 cm	91.25	91.75	93.25	73.75	87.5**
	$F_{accounted}$	F_{crit}*	F_{crit}**			
Planting distances	10.62	4.459	8.649			
Years	14.31	3.838	7.006			

Number of shoots per plant was accounted for 10 sage plants for each variant in each replication. Planting density significantly affected the number of shoots per plant

since the first year. Number of shoots per plant was increased from the first to the third year of cultivation, and there was shown a significant decrease in the fourth year of cultivation for both ecotypes under study. The highest shoot number per plant was observed for the planting distances (60 cm x 30 cm) with a four year mean of 32.01 and 31.5 shoots per plant for Dutch sage ecotype and Albanian sage ecotype, respectively. Differences between variants (planting distances) were significant for both probability levels (95% and 99%) (Table 3).

Table 3. Number of shoots per plant of two *Salvia officinalis* L ecotypes (Dutch and Albanian ecotypes), according to different planting densities and different years of cultivation (mean values) (** significant at $p \leq 0.01$ and * significant at $p \leq 0.05$).

Sage ecotype	Variants	2010	2011	2012	2013	Mean
Dutch ecotype	60 cm x 30 cm	34	34	35	25.03	32.01**
	60 cm x 25 cm	30.75	30	32.25	23	29.0**
	60 cm x 20 cm	28	28	29.25	21.25	26.6**
ANOVA	$F_{accounted}$	F_{crit}*	F_{crit}**			
Planting distances	131.837	4.459	8.649			
Years	139.249	3.838	7.006			
Albanian (Dibra's) ecotype	60 cm x 30 cm	32.25	33.75	34.75	25.25	31.5**
	60 cm x 25 cm	28.75	28.75	35.25	22	28.7**
	60 cm x 20 cm	27.25	27.25	36.3	19.5	27.6**
ANOVA	$F_{accounted}$	F_{crit}*	F_{crit}**			
Planting distances	17.623	4.459	8.649			
Years	24.508	3.838	7.006			

Lateral shoot length (cm). Lateral shoot length is a very important yield indicator linked to herb yield and quality. Lateral shoot length was measured for 10 sage plants for each variant in each replication, taking 10 lateral shoots starting from the fourth node of the main shoot. The obtained data showed that planting distances significantly affected the lateral shoot length since the first year. For the Dutch sage ecotype, there were observed significant differences between variants (planting density) and between years for both probability levels (95% and 99%), while, for the Albanian sage ecotype, differences between variants were significant for probability level of 95%, but not significant between years for the same variant for both probability levels. The highest four years mean value of lateral shoot length (cm) was measured for the Albanian sage ecotype planted in distances 60 cm x 30 cm (13.9 cm), while the lowest value was measured for the Dutch sage ecotype planted in distances 60 cm x 20 cm (11.1 cm) (Table 4).

Table 4. Lateral shoot length (cm) of two *Salvia officinalis* L ecotypes (Dutch and Albanian ecotypes), according to different planting densities and different years of cultivation (mean values) (** significant at $p \leq 0.01$ and * significant at $p \leq 0.05$).

Sage ecotype	Variants	2010	2011	2012	2013	Mean
Dutch ecotype	60 cm x 30 cm	13	12.8	13.95	11.62	12.84**
	60 cm x 25 cm	11.9	11.78	12.65	11.4	11.93**
	60 cm x 20 cm	10.95	10.68	12.1	10.6	11.1**
ANOVA	$F_{accounted}$	F_{crit}*	F_{crit}**			
Planting distances	57.713	4.459	8.649	57.71		

Years	16.69	3.838	7.006	16.69		
Albanian (Dibra's) ecotype	60 cm x 30 cm	14.85	14.9	13.72	12.1	13.9*
	60 cm x 25 cm	13.83	13.7	13.7	13.57	13.7*
	60 cm x 20 cm	12.83	12.58	12.53	12.37	12.6*
ANOVA	$F_{accounted}$	F_{crit}*	F_{crit}**			
Planting distances	7.078	4.459	8.649			
Years	1.73	3.838	7.006			

Number of leaves per shoot was accounted from 10 lateral shoots for each of 10 sage plants in each variant in each replication. The Dutch sage ecotype, planted in distances 60 cm x 30 cm was shown to have the highest number of leaves per shoot (12.47). There were observed significant differences between variants (planting densities) and between years for both probability levels, for both sage ecotypes (Table 5).

Table 5. Number of leaves per shoot of two *Salvia officinalis* L ecotypes (Dutch and Albanian ecotypes), according to different planting densities and different years of cultivation (mean values) (** significant at $p \leq 0.01$ and * significant at $p \leq 0.05$).

Sage ecotype	Variants	2010	2011	2012	2013	Mean
Dutch ecotype	60 cm x 30 cm	13.78	13.2	13.03	10.5	12.63**
	60 cm x 25 cm	11.53	11.43	11.43	9.52	10.98**
	60 cm x 20 cm	10.48	10.48	10.5	9.17	10.2**
ANOVA	$F_{accounted}$	F_{crit}*	F_{crit}**			
Planting distances	59.662	4.459	8.649			
Years	17.762	3.838	7.006			
Albanian (Dibra's) ecotype	60 cm x 30 cm	11.43	11.38	11.4	10.37	11.1**
	60 cm x 25 cm	10.86	10.83	10.58	9.4	10.4**
	60 cm x 20 cm	10.27	10.25	10.2	8.85	9.9**
ANOVA	$F_{accounted}$	F_{crit}*	F_{crit}**			
Planting distances	189.5498	4.459	8.649			
Years	86.196	3.838	7.006			

Leaf length (cm) and leaf width (cm) were measured for 10 leaves taken from the middle part of 10 lateral shoots for each of 10 sage plants in each variant in each replication. The observed data showed that planting density significantly affected the leaf biometrical indicators, such as leaf length, leaf width and length of petiole. The Albanian sage ecotype, planted in distances 60 cm x 30 cm was shown to have the largest leaves [9.63 cm (length) x 2.69 cm (width)], while the smallest leaves were shown for Dutch sage ecotype planted in distances 60 cm x 20 cm [6.64 cm (length) x 2.08 cm (width)]. For the Dutch sage ecotype, there were observed significant differences between variants (planting densities) for both probability levels (95% and 99%), but not between years. For the Albanian sage ecotype, differences between variants were significant for 95%, but were not confirmed for 99%. Differences between years were not confirmed for both probability levels. In all variants, leaf biometrical parameters were larger for the Albanian sage ecotype (Tables 6 and 7).

Table 6. Mature leaf length (cm) of two *Salvia officinalis* L ecotypes (Dutch and Albanian ecotypes), according to different planting densities and different years of cultivation (mean values) (** significant at $p \leq 0.01$ and * significant at $p \leq 0.05$).

Sage ecotype	Variants	2010	2011	2012	2013	Mean
Dutch ecotype	60 cm x 30 cm	7.82	7.82	8.0	7.82	7.87**
	60 cm x 25 cm	7.25	7.3	7.15	7.32	7.26**
	60 cm x 20 cm	6.57	6.7	6.7	6.57	6.64**
ANOVA	$F_{accounted}$	F_{crit}*	F_{crit}**			
Planting distances	308.76	4.458	8.649			
Years	0.3877	3.837	7.006			
Albanian (Dibra's) ecotype	60 cm x 30 cm	9.52	9.65	9.75	9.78	9.63**
	60 cm x 25 cm	8.57	8.65	8.62	8.73	8.64**
	60 cm x 20 cm	7.6	7.55	7.62	7.48	7.56**
ANOVA	$F_{accounted}$	F_{crit}*	F_{crit}**			
Planting distances	1124.99	4.459	8.649			
Years	0.80798	3.838	7.006			

Table 7. Mature leaf width (cm) of two *Salvia officinalis* L ecotypes (Dutch and Albanian ecotypes), according to different planting densities and different years of cultivation (mean values) (** significant at $p \leq 0.01$ and * significant at $p \leq 0.05$).

Sage ecotype	Variants	2010	2011	2012	2013	Mean
Dutch ecotype	60 cm x 30 cm	2.48	2.48	2.48	2.38	2.46**
	60 cm x 25 cm	2.33	2.43	2.28	2.5	2.39 **
	60 cm x 20 cm	2.15	2.08	2.1	2.0	2.08**
ANOVA	$F_{accounted}$	F_{crit}*	F_{crit}**			
Planting distances	35.164	4.459	8.649			
Years	0.1746	3.838	7.006			
Albanian (Dibra's) ecotype	60 cm x 30 cm	2.83	2.88	2.95	2.08	2.69*
	60 cm x 25 cm	2.7	2.6	2.7	2.6	2.65*
	60 cm x 20 cm	2.33	2.18	2.18	2.35	2.26*
ANOVA	$F_{accounted}$	F_{crit}*	F_{crit}**			
Planting distances	5.836	4.459	8.649			
Years	0.785	3.838	7.006			

Length of petiole (cm) and content of the stalks in the herb (%). The observed data showed that planting density significantly affected the length of petiole, as well as the content of the stalks in the herb for both sage ecotypes under study. Results showed that the content of the stalks in the herb for the Albanian sage ecotype was lower than the Dutch sage ecotype which confirms the highest quality of the Albanian sage. Observed results were confirmed for both probability levels (Table 8 and 9).

Table 8. Mature leaf length of petiole (cm) and content of stalks in the herb (%) of two *Salvia officinalis* L ecotypes (Dutch and Albanian ecotypes), according to different planting densities and different years of cultivation (mean values) (** significant at $p \leq 0.01$ and * significant at $p \leq 0.05$).

Sage ecotype	Variants	2010	2011	2012	2013	Mean
Dutch ecotype	60 cm x 30 cm	1.8	1.85	1.85	1.8	1.83**
	60 cm x 25 cm	1.5	1.63	1.68	1.63	1.61**
	60 cm x 20 cm	1.3	1.43	1.45	1.43	1.40**

ANOVA	$F_{accounted}$	F_{crit}*	F_{crit}**			
Planting distances	252.0353	4.458	8.649			
Years	7.7624	3.837	7.006			
Albanian (Dibra's) ecotype	60 cm x 30 cm	2.1	2.08	2.15	2.03	2.09**
	60 cm x 25 cm	1.9	1.8	1.85	1.75	1.83**
	60 cm x 20 cm	1.8	1.63	1.67	1.58	1.67**
ANOVA	$F_{accounted}$	F_{crit}*	F_{crit}**			
Planting distances	181.6443	4.459	8.649			
Years	7.3624	3.838	7.006			

Table 9. Content of stalks in the herb (%) of two *Salvia officinalis* L ecotypes (Dutch and Albanian ecotypes), according to different planting densities and different years of cultivation (mean values) (** significant at $p \leq 0.01$ and * significant at $p \leq 0.05$).

Sage ecotype	Variants	2010	2011	2012	2013	Mean
Dutch ecotype	60 cm x 30 cm	23.5	23.65	24.6	24.88	24.16**
	60 cm x 25 cm	22.5	22.55	23.35	23.58	23.00**
	60 cm x 20 cm	21.67	21.77	22.75	23.475	22.42**
ANOVA	$F_{accounted}$	F_{crit}*	F_{crit}**			
Planting distances	181.64	4.459	8.649			
Years	7.3624	3.838	7.006			
Albanian (Dibra's) ecotype	60 cm x 30 cm	20.97	20.8	22.38	22.45	21.65**
	60 cm x 25 cm	20.45	20.4	20.53	21.1	20.62**
	60 cm x 20 cm	19.27	19.22	18.98	20.35	19.46**
ANOVA	$F_{accounted}$	F_{crit}*	F_{crit}**			
Planting distances	181.6443	4.459	8.649			
Years	7.3624	3.838	7.006			

Total herb yield (q ha^{-1}). During the first year there was applied one cut, on September 10, 2010, while during the other consecutive years, there were applied two cuts, at the full flowering stage, corresponding on June 5-15 and September 5-15, each year. The observed results showed that plants density significantly affected the first, second and total herb yield of both sage ecotypes. There was observed that plants density significantly affected the first cut, second cut and total herb yield of both *Salvia officinalis* L ecotypes, grown under Maqellara, Dibër, climate conditions. The highest yields for all variants were observed during the second and the third year of sage cultivation for both sage ecotypes. There were observed not significant differences between 2nd and 3rd year of cultivation for the same variant and the same ecotype. During the 4th year, the total herb yield was decreased significantly (33-42%) for the all variants (planting densities) and for both ecotypes. Maximum four years mean total herb yield was observed for the variant 2 (planting distances of 60 cm x 25 cm or plants density of 6.6 sage plants per m^2) by 21.69 q ha^{-1} and 22.5 q ha^{-1} for the Dutch sage ecotype and the Albanian sage ecotype, respectively (Table 10). Although the sage yield decreases after the third year, using 80-120 q ha^{-1} limestone can be a possibility keeping the sage until the 5th year (Doda *et al.*, 2014; Gjoni, 2009).

Table 10. Total herb yield (q ha^{-1}) of two *Salvia officinalis* L ecotypes (Dutch and Albanian ecotypes), according to different planting densities and different years of cultivation (mean values) (** significant at $p \leq 0.01$ and * significant at $p \leq 0.05$).

Sage ecotype	Variants	2010	2011	2012	2013	Mean
Dutch ecotype	V1	13.15	23.83	24.99	16.71	19.67**
	V2	14.58	27.01	27.7	17.48	21.69**
	V3	13.74	24.73	25.32	14.6	19.60**
ANOVA	$F_{accounted}$	F_{crit}*	F_{crit}**			
Planting distances	14.458	4.458	8.649			
Years	175.87	3.837	7.006			
Albanian (Dibra's) ecotype	V1	14.33	24.91	25.85	14.82	19.98**
	V2	15.65	28.48	28.47	17.35	22.49**
	V3	14.6	26.18	25.8	12.35	19.73**
ANOVA	$F_{accounted}$	F_{crit}*	F_{crit}**			
Planting distances	15.2773	4.459	8.649			
Years	136.4417	3.838	7.006			

Observed results showed that planting distances (plants density) did significantly affect morphological leaf indicators and herb yield of both studied sage ecotypes, the Dutch sage ecotype and the Albanian sage ecotype. The highest total herb yield and higher herb quality were achieved using planting distances 60 cm x 25 cm or 66000 sage plants ha^{-1} (6.6 sage plants per m^2), that's why we recommend it for sage grown under Maqellara, Dibër, climate conditions.

CONCLUSIONS

Planting distances significantly affected the morphological and yield indicators of studied sage (*Salvia officinalis* L) ecotypes, the Dutch sage ecotype and the Albanian sage ecotype. The highest yearly and total herb yield was obtained using the planting distances of 60 cm x 25 cm (or 66000 sage plants ha^{-1}), with a four year mean yield of 21.7 q ha^{-1} and 22.5 q ha^{-1}, for the Dutch sage ecotype and for the Albanian sage ecotype, respectively. Recommended planting distances for both sage ecotypes grown in Maqellara, Dibër, climate conditions, is 60 cm x 25 cm.

References

Ahmataj, H. (1996) Cultivation of some aromatic and medicinal plants in Albania. 123 p: pp. 75-87.

Ahmataj, H. & Çeku, K. (1988) "Cultivation of the ethero-oil and medicinal plants", 354 p: pp. 123-129.

Albanian Research Institute for Forests and Pasture (ARIFP). (1988) Inventory of the ethero- oil and medicinal plants in Albania: pp. 20, 30, 55.

Asllani, U. (2000) Chemical composition of the Albanian sage oil (*Salvia officinalis* L.). *J. Essent. Oil Res*. 12: pp. 79-84.

Asllani, U. (2004) Essences of the aromatic and medicinal plants in the Albanian regions: 426 p: pp. 218-235.

Akhondzadeh, S., Noroozian, M., Mohammadi, M., Ohadinia, S., Jamshidi, A. H., Khani, M. (2003) "*Salvia officinalis* extract in the treatment of patients with mild to moderate Alzheimer's disease: a double blind, randomized and placebo-controlled trial". *J Clin Pharm Ther* **28** (1): pp. 53–59. doi:10.1046/j.1365-2710.2003.00463.x. PMID 12605619.

Bardhi, N. (2013). "Aromatic and Medicinal Plants" (Lectures), 268 p: 73-105.

Bardhi, N., Rusinovski, I., Mero, Gj. (2001) Oil Plants (254 p): pp. 127-138.

Baricevic, D., Bernath, J., Maggioni, L., Lipman, E. (2002) Report of a Working Group on Medicinal and Aromatic Plants: First Meeting, 12-14 September 2002, Gozd Martuljek, Slovenia. 161 p: pp.3-147.

Clebsch, B., Barner, C. D. (2003). *The New Book of Salvias*. Timber Press: pp. 216-220.

Çeku, K. (1984) Cultivation of the aromatic and medicinal plants. 176 p: 43-58.

Demiri, M. (1971) Excursionist Flora of Albania (735 p): pp. 335.

Doda, Q., Bardhi, N., Teqja, Z., Mero, Gj., Kallço, I., Zeka, B. (2014). Effects of Different Limestone Rates on Yield and Yield Indicators of a Sage (*Salvia officinalis* L.) Ecotype. Online International Interdisciplinary Research Journal, {Bi-Monthly}, Volume-IV, Issue-IV, July-Aug 2014: pp. 7-16.

Dos Santos-Neto, L. L., De Vilhena, T. M., Medeiros-Souza, P., De Souza, G. A. (2006) The Use of Herbal Medicine in Alzheimer's Disease - A Systematic Review. (Free full text). *Evidence-based complementary and alternative medicine: eCAM* **3** (4): 441– 445. doi:10.1093/ecam/nel071. PMC 1697739. PMID 17173107.

Geneva, M. P., Stancheva, I. V., Boychinova, M. M., Mincheva, N. H., Yonova, P. A. (2010). Effects of foliar fertilization and arbuscular mycorrhizal colonization on *Salvia officinalis* L. growth, antioxidant capacity, and essential oil composition. J. Sci. Food Agric., 90: pp. 696-702. doi: 10.1002/jsfa.3871.

Gjoni, Z. (2009) Harvesting and collection of the aromatic and medicinal plants. 112 p: pp. 75-89.

Haska, H., Bacu, A., Marko, O. (2005) Sage – characteristics and usage: 112 p.

Hyso, M., Çobaj, P. (2005) Summary of the work done within the Assessment and Collection of Germplasm Program: pp. 25-52.

Kintzios, S. E. (2000). *Sage: The Genus Salvia*. CRC Press: pp. 10–11.

Kokalari, P., Sima, Z., Xinxo, P. (2007) Medicinal plants in the family. 254 p: pp. 135-159.

Kumar, R., Sharma, S., Pathania, V. (2013). Effect of shading and plant density on growth, yield and oil composition of clary sage (*Salvia sclarea* L.) in north western Himalaya. Journal of Essential Oil Research, Vol. 25 (1): pp. 23-32.

Kutrolli, F. (2010) Cultivation and processing of the medicinal aromatic plants. 136 p: pp. 45- 57.

Lorraine, H. (2012) *RHS Latin for gardeners*. United Kingdom: Mitchell Beazley: p. 224.

Marko, O., Dishnica, T. (2002) Study and preservation of the genetic material of ethero-oil and wild type plants under risk for seed and seedling production. Sc. Report: 32 p.

Ndoja, H. (2001) Popular Medicine, ancient culture in the health service. 154 p: pp. 25-27.

Papadhopulli, G. (1987) Medicinal and aromatic plants of Albania. 425 p: pp. 123-137.

Papakroni, H. (2001) Used Programs on computer - (2) Excel. Teaching Student's Book, Agricultural University of Tirana, 275 p: pp. 165-175.

Paparisto, K., Demiri, M., Mitrushi, I., Qosja, Xh. (1988) Albanian Flora, Vol. 1, Tirana, Albania: pp. 192.

Perry, E. K., Pickering, A. T., Wang, W. W., Houghton, P., Perry, N. S. L. (2007) "Medicinal plants and Alzheimer's disease: Integrating ethnobotanical and contemporary scientific evidence". *Journal of alternative and complementary*

medicine (New York, N.Y.) **4** (4): 419–428. doi:10.1089/acm.1998.4.419.

Piccaglia, R., Marotti, M., Dellacecca, V. (1997). Effect of Planting Density and Harvest Date on Yield and Chemical Composition of Sage Oil. Journal of Essential Oil Research Vol. 9 (2): pp.187-191.

Plaku, F., Salillari, A., Çullhaj, Z. (2014) Medicinal and aromatic plants of Albania and their values. 689 p: pp. 234-239.

Radanović, D., Jevđović, R., Dražić, S. (2000). Influence of plant density and nitrogen fertilization on yield and quality of sage (*Salvia officinalis* L.). http://www.amapseec.org/cmapseec.1/papers/pap_p037.htm.

Stearn, W. T. (2004). Botanical Latin. Timber Press (OR): p. 456.

Vangjeli, J., Ruci, B., Mullaj, A. (1995) Red Book – Rescued and Rare Plants of Albania. Publication of the Albanian Academy of Sciences: pp. 49, 53, 55.

WBA (World Bank Albania). (October 2002) "An Agricultural Strategy for Albania", 157 p: pp. 101-103.