EFFECTS OF PLANTING DENSITY AND HARVESTING TIME ON LEAF AND ESSENTIAL OIL YIELD OF BAY LAUREL (*Laurus nobilis* L.) CULTURED IN SHRUB FORM

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Bay laurel leaves and fruits are usually obtained from naturally grown plants. Therefore, it is not always possible to obtain the product at the same quality. For this reason, plantation for leaf production should be established separately from fruit production to obtain quality products. The aim of the study was to investigate the feasibility of the production of the bay laurel plant such as field crops in a shrub form. It is also important to know the ontogenetic variability on the amount of active substance and determine suitable plant density and appropriate harvesting time in order to increase leaf yield and essential oil with desired quality characteristics. Three different planting frequencies (1x1.5m; 1x3 m; 1x1x3 m) and three different harvesting times (one form per year, two forms per year and two years per form) were applied to the experiment. The experiment was established with a total of 1080 seedlings. In the experiment, the shoot length (16,84 - 31,50 cm), number of shoots (4,77 - 16,00 plants/plant), fresh weight (6,88 - 27,80 kg/da), dry weight (4,15 - 26,63 kg/da), dry leaf yield (2,57 - 17,29 kg/da), leaf area (20,41 - 24,56 cm²), chlorophyll SPAD value (32,36 - 39,5 kg/da), total ash content (7,96 - 11,46 %), essential oil content (2,06 - 3,12%) and essential oil yields were determined.

Keywords: Bay laurel, essential oil, plant density, harvesting time

INTRODUCTION

Bay laurel is an evergreen and dioic forest tree or shrub with a yellow flower and small and oval-black fruit. Bay laurel, which is originated from Asia, is grown naturally in Turkey, Greece, Italy, Spain, Portugal, France, Yugoslavia, Syria, Morocco, Algeria, Mediterranean Islands, California, Mexico and the Canary Islands (Ercan, 1983; Baytop, 1999). It is especially grown in the Mediterranean coasts and in the Aegean, Marmara and Black Sea borders and in the inner parts of these coasts in Turkey (Baytop, 1991). Leaves are used as spices, 2-5 cm wide and 5-10 cm in length, hard, dull, short stem, hairless, bright, wavy sides, dark green, yellowish gray green, elliptical, aromatic, spicy and bitter taste (Akgül, 1993). Flowering period varies depending on the region and species between February and May. The ripening time of the fruits is mid of October to November. After ripening the fruits spontaneously pour out. The shooting ability is excessive (Cengiz, 1979).

Laurel tree is spread over 131 862 hectares of land in Turkey. Turkey is one of the few countries that export the highest quality bay leaf and meets about 90% of the world's bay laurel leaf requirement. Among the medical and aromatic plants exported, bay laurel leaf is the most exported products with cumin, thyme, carob and capari (Şafak and Okan, 2004). Bay leaves and fruits used in processing in our country are generally obtained from naturally grown plants. The lack of cultivation of bay laurel prevents production with standard raw materials and excessive cuttings cause genetic resources to be destroyed.

It is stated that bay leaf has antioxidant, analgesic, anti-inflammatory, anticonvulsant (antiepileptic) and antifungal benefits (Simic *et al.*, 2004; Sayyah *et al.*, 2002; Sayyah *et al.*, 2003; Rodilla *et al.*, 2008). The bay leaves contain essential oil. The amount of essential oil and the physicochemical structure of oil varies depending on the production

area, production time, and the age of the shoots. The amount of essential oil is higher in young shoots than in older shoots. In addition, the rate of volatile oil is higher in low-lying coastal regions (Acar, 1987, Acar, 1988, Ceylan and Özay, 1990, Gültekin, 1997). The main components of bay leaf essential oil are 1,8-cineole, trans-sabinene hydrate, α -terpinyl acetate, methyl eugenol, sabinene, eugenol and α -pinene (Tanker and Tanker, 1976, Acar, 1987, Kekelidze *et al.*, 1987, Ceylan and Özay 1990, Baytop, 1991, Akgul, 1993, Gültekin, 1997, Kilic *et al.*, 2004, Mohammadreza, 2008, Ayanoglu *et al.*, 2010).

The aim of the study was to investigate the feasibility of the production of the laurel plant such as field crops. Thus, without waiting for many years for leaf production, it will be possible to increase the productivity of leaf and essential oil to be taken from the unit area and to obtain the product with desired quality characteristics. It is also important to know the ontogenetic variability of the amount of active substance during the growth period of a plant in order to determine the appropriate harvesting time of the medical plants. Therefore, determining the most suitable harvesting period in terms of leaf and volatile oil yield in bay laurel cultivation in bush form is another aim of the study.

MATERIALS AND METHODS

Plant Materials

The plants used in the experiment were obtained by sowing bay laurel seeds in pots. Seedlings were planted to the trial area when they were one year old.

Methods

The bay laurel plants were planted in the trial area in March. Three different planting density (1x1.5m; 1x3m; 1x1x3m) and three different harvesting times (twice a year, once a year and every two years) were applied in the experiment. One harvest per year (November), two harvests per year (July and November), and harvest (November) every two years. July is entering the summer dormant period and November is the period that trees entered to rest in the region.

The experiment was established with 4 replications and consisted of 36 plots in total. The size of each plot is 72 m² and the number of plants in the plots are 20, 30 and 40 plant/plot depending on the planting density. 1080 plants were used in the experiment. The plants were irrigated by drip irrigation method. Trial pattern was split plot on randomized blocs. The plants were harvested at 25-30 cm height on the first harvesting period (Sarı *et al.*, 2010). Dry weight (kg/da), dry leaf yield (kg/da), leaf area (cm²), chlorophyll SPAD value, essential oil content (%), essential oil yield (l/da) and total amount of ash (%) were determined. Dry leaf samples of bay laurel hydro distilled for three hours and the essential oil ratio were determined volumetrically by using Neo-Clevenger apparatus.

RESULTS AND DISCUSSION

The results of analysis of the essential oils obtained by water distillation are shown in Table 2.

Two years results about shoot length, number of shoots, leaf area, chlorophyll content and total ash content are given in Table 1. Shoot lengths of plants were ranged

between 16,84-31,50 cm. Number of shoots were ranged between 4,77 to 16,00 piece/plant.

Contrast to shoot number, shoot lengths were found lower in twice a year harvest. There was no significant difference between once a year harvest and twice a year harvest. Leaf area of the plants were found between 20,41-24,56 cm². The lowest leaf area value found in once a year harvest while the highest results were obtained from twice a year harvest in the first year. Chlorophyll content of the samples were measure with SPAD chlorophyll meter. SPAD values were ranged between 32,26-39,21. The highest value were obtained in the first year twice a year harvest with 40 plants/plot application. Total ash content were ranged between 7,96-11,46%. The highest value were obtained once a year harvest in the first year of the study.

Table 1. Results of shoot length, number of shoots, leaf area (cm²), chlorophyll content (SPAD value) and total ash content due to harvesting period and planting densities

Year	Plant density	Harvest	Shoot length	Number of shoots	Leaf area	Chlorophyll Content	Total Ash Content
2015	1 m x 1 m (40 plant/7 2 m ²)	2 times/year	17,11	13,83	21,13	39,21	11,35
		1 time/year	31,42	10,18	21,45	36,15	9,76
		1 time/2 years	—	—	—	—	—
	1 m x 1 m x 3 m (30 plant/7 2 m ²)	2 times/year	17,13	12,52	21,02	32,80	10,85
		1 time/year	31,50	7,96	21,45	35,83	11,46
		1 time/2 years	—	—	—	—	—
	1 m x 3 m (20 plant/7 2 m ²)	2 times/year	16,84	16,00	24,56	33,41	9,05
		1 time/year	27,60	7,50	21,21	32,36	10,98
		1 time/2 years	—	—	—	—	—
	1 m x 1 m (40 plant/7 2 m ²)	2 times/year	14,40	11,55	21,65	35,76	10,46
2016		1 time/year	30,16	10,17	21,39	36,18	8,68
		1 time/2 years	21,01	5,95	21,08	32,26	10,05
	1 m x 1 m x 3 m (30 plant/7 2 m ²)	2 times/year	16,59	12,05	21,54	33,49	8,85
		1 time/year	27,89	6,96	21,13	36,04	8,13
		1 time/2 years	26,69	4,96	21,77	34,12	9,79
	1 m x 3 m (20 plant/7 2 m ²)	2 times/year	19,45	10,78	23,81	33,72	9,82
		1 time/year	31,44	6,04	20,41	32,40	7,96
		1 time/2 years	17,10	4,77	21,12	33,51	10,02

The results of the fresh weight, dry weight, dry leaf yield, essential oil content and essential oil yields were given in Table 2. Fresh weight results were found as lowest in

6,88 kg/da in once in two year harvest (20 plant/plot) while highest value found as 27.80 kg/da in once a 2 years harvest (40 plant/plot). The lowest values for the dry weight in the experiment were obtained from the applications which were formed every two years with 4,15 kg/da and 20 plants on the plots, and the highest dry weight values were obtained from applications with an average of 26.63 kg/da once a year harvest and 40 plants on the plots .

The lowest values for dry leaf yield in the experiment were obtained from applications with 2.57 kg/da every 2 years and 20 plants in the plot. The highest dry leaf yield values were obtained with an average of 17,29 kg/plant once a year harvest and 40 plants in the plot applications.

Although the values are generally close to the other applications in twice a year harvest, it is determined that is not suitable when considering the labor costs. On the other hand, when the plants harvested in July, they are unable to produce enough shoots for harvest until November. Lower yield values were obtained in the plots with 20 plants/plot.

Table 2. Results of fresh weight, dry weight, dry leaf yield and essential oil content due to the different harvesting period and planting densities

Year	Plant density	Harvest	Fresh Weight	Dry Weight	Dry Leaf Yield	Essential Oil Content
2015	1 m x 1 m (40 plant/72 m ²)	2 times/year	27,55	13,26	11,95	3,12
		1 time/year	25,80	26,63	13,66	2,10
		1 time/2 years	—	—	—	—
	1 m x 1 m x 3 m (30 plant/72 m ²)	2 times/year	20,28	9,74	8,84	2,62
		1 time/year	18,32	17,61	11,12	2,09
		1 time/2 years	—	—	—	—
	1 m x 3 m (20 plant/72 m ²)	2 times/year	12,51	6,16	5,91	2,80
		1 time/year	17,34	11,46	7,14	2,06
		1 time/2 years	—	—	—	—
	1 m x 1 m (40 plant/72 m ²)	2 times/year	18,45	8,20	9,01	2,36
		1 time/year	25,05	23,36	17,29	2,80
		1 time/2 years	27,80	16,01	9,37	2,15
2016	1 m x 1 m x 3 m (30 plant/72 m ²)	2 times/year	17,82	8,87	7,55	2,96
		1 time/year	17,96	17,19	10,12	2,11
		1 time/2 years	20,64	12,68	7,75	2,90
	1 m x 3 m (20 plant/72 m ²)	2 times/year	11,99	5,86	4,51	2,67
		1 time/year	17,26	11,21	6,99	2,99
		1 time/2 years	6,88	4,15	2,57	2,88

There was no significant difference among the applications as regard to essential oil contents. Özcan and Chalchat (2005), reported that bay laurel essential oil contents vary between 1.4-2.6 % in their studies. Ayanoğlu *et al.* (2010), found that the leaf area

ranged from 5.78 cm² to 49.00 cm², chlorophyll content 35.70-66.90, and the essential oil content from 0.45 to 6.00 % in their study conducted in native flora of Hatay province in Turkey.

CONCLUSION

According to the two years harvest values obtained in the study, it is obvious that the plantation density with 1 x 1.5 m had greater values for yield and yield components. These are preliminary results. However, bay laurel is a long-lived perennial plants, the studies and investigations will be continued on the densities. The planting pattern of 1m x (1m x 3m) may be preferred as it is a suitable model for machine cultivation.

Twice a year harvests are definitely not recommended. The plants are unable to produce enough shoots for second harvest until November. For this reason, the harvests carried out every two years become more efficient and after the harvest in two years. The most important result of the study was to reveal that the bay laurel plant is possible to produce such as field crops. Thus, it was determined that the bay laurel plant could easily be produced for leaf and the essential oil rather than destruction of the natural vegetation.

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