



Assessment of density and cultivation type on growth and yield of two cultivars of basil (*Ocimum basilicum* L.)

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Abstract

The genus *Ocimum* has up to 60 species that *Ocimum basilicum* L. is the most important commercially species. It is cultivated throughout the world. This species often use as vegetables and health industry such as toothpaste, due to good favorite of its oil. This study was done in spring and summer of 2010 in the field about 200 m² as 4×1m plots on two cultivars of *Ocimum*. Statistical design was completely randomized block design with 3 replications. Analysis of variance was done by Duncan test in 5% level by MSTATC software. Correlation coefficient analyzed by SPSS software. Results showed that the highest level of dry leaf weight, total dry weight and plant height obtained in green basil that cultivated two- row with 100 plants per m². Leaf dry weight and total dry weight were calculated in unit area. However leaf and total dry weight decreased per plant, due to increasing plant density in unit area, whole and leaf dry weight would increase totally. Also, maximum number of spike per plant, lateral shoot and leaf area index per plant obtained in green cultivar with two-row and density of 40 plants per m².

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Introduction

Basil (*Ocimum basilicum* L.) is annual and belongs to the family of Lamiaceae. There are many subspecies and cultivars in the genus *Ocimum*, because it pollinates easily with other species. The genus has up to 60 species, which is sweet basil (*Ocimum basilicum*) is of economic importance and cultivated throughout the world (Balyan and Sobti, 1990). The species is herbaceous, 30-60 cm height and usually with very much foliage. The height of plant depends on climatic condition of location. It also, has many aromatic components (Prakash, 1990). Growth period of basil lasts about 6 months and depending on growth condition, it could be harvested up to 3 times. Vegetative yield of dry matter is reported about 1.2-2 t/hect (Omidbaigi, 2000), as it could achieve 8-10 (-12) ton/hect for fresh vegetative yield (Prakash, 1990). Vomel and Ceylan (1997) reported that *Ocimum basilicum* L. has average of 1551 kg ha⁻¹ green herb yield and the highest yield was reached fewer than 15 cm space between rows. Gill and Randhawa (2000) indicated that the highest drug herb yield was obtained from 40×20 cm plant density. El-Gendy *et al.* (2001) reported that the highest yield of *Ocimum* obtained under 15 cm between rows.

Dadvand and coworkers (2006) studied effects of nitrogen fertilizer and plant density on basil. They found that density had significant effect on dry matter and essential oil yield of basil at 0.01 levels. They reported that density had no significant effect on ratio (percentage) of essential oil; while increasing of essential oil yield had been resulted in increased dry matter yield in a unit area. Chris and coworkers (2002) found that by increasing number of plants from 2 to 16 in m², biological yield would increase; but weight of each plant decrease when number of plants reaches to 8 and upper and density had no effect on essential oil level. Farooqi (2005) reported that cultivation spacing by 30×45 cm is the best for basil cultivation with the yields of 75 and 3.73 ton/hect for vegetative and seed production. Omidbaigi (2000) stated that the best interval between rows in direct cultivation is 40 to 50 cm. Arabaci and Bayram (2004) reported that the highest essential oil ratio

obtain under non-nitrogen fertilizer condition with 20×20 cm plant spacing. Pancic and Kosciuska (1990) in a two years experiment found that maximum yield for vegetative fresh weight obtain in spacing of 30×50 cm and the minimum yield for 30×70 cm. Toghray (2006) stated that by decreasing plant density in unit area, long time need for early growth. Azizi and colleagues (2004) investigated effects of different levels of vermicompost on growth index and essential oil level in basil.

The aim of this research was to determine agronomic characteristics of basil and to identify optimum plant density under different cultivars and cultivation type (one and two row) between plants for maximum vegetative yield.

Materials and methods

This research was done in Imam Khomeini Higher Education Center (IHEC) farm located in the city of Karaj with the area of 200m², in spring and summer of 2010 and 2012. Physical and chemical properties of farm soil were analyzed (table 1). Two cultivars of healthy seeds of green and purple basil with high purity and nominal strength that were prepared from the gene bank of Seed and Plantlet Breeding Institute (SPBI) were used. The experiment was carried out with 3 replications in a completely randomized block design. The cultivars (green and purple) were cultivated in two methods (one and two-row) and with density in 4 different levels (40, 60, 80 and 100 plants per m²). Manure was homogeneously applied to all the patches, as the base fertilizer for the fertility of soil before cultivation. After that, the seeds were sown and covered by soft soil. Sampling from grown plants was done according to standards. Plant height, number of shoot and leaves, whole plant dry weight, biological yield and harvest index were measured. Samples were dried at 30°C for 48 h to determine dry weight. Leaf area index was measured by scanning and analyzing with AutoCAD software. Variation of leaf dry weight (LDW) and total dry weight (TDW) measured based on 8 samples in each plot. Totally, each measure obtained from at least 8 samples. Significant differences between means were done

using multivariate Duncan test at 5% by MSTATC software. Correlation coefficient was calculated by SPSS software.

Results

Time to 10% flowering

Simple effects of cultivar and cultivation type on the time of 10% flowering were significant at 0.01 levels.

One-row cultivation on time of 10% flowering had higher values than two-row cultivation. Results showed that 100 plants per m² had the shortest time for 10% flowering and 40 plants per m² were longest (table 2). Totally, purple basil in one-row cultivation longest time and green basil in two-row had shortest time of 10% flowering.

Table 1. physical and chemical features of soil farm.

Fe (ppm)	B (ppm)	Zn (ppm)	Mg	Sand (%)	Silt (%)	Clay (%)	Soil texture	Ca (%)	EC	Saturation (%)	K (ppm)	P (ppm)	N (% for whole)	C (% organic)	Depth (cm)
3.94	0.82	0.92	6.5	66	20	14	L-C	9.29	3.1	26.08	224.6	12.2	0.08	0.76	0-30

Leaf area index

Results showed that effects of cultivar and density on leaf area index are significant at 0.01 levels (Table 2). Lowest index was for 100 plants in m² at flowering phase. As a whole, green basil in two-row cultivation had higher levels than purple basil in one-row. Also, green basil by the compaction of 40 plants per m² had

the highest values and purple basil with 100 plants per m² had lowest values for leaf area index.

Results obtained from correlation coefficient showed that leaf area index had positive relation to leaf and whole plant dry weight at 0.01 levels and with harvest index at 0.05 levels (table 2).

Table 2. analysis of variance for triple effects of cultivar, cultivation type and density on morphological characteristics in basil.

Source of Variation	Degree of freedom	Mean squares									
		Leaf area index	Leaf dry weight	Plant dry weight	time to 10% flowering	No. of leaf	Dry weight of other plant parts	Plant height	Spike Length		
Replication	2	0/5289 n.s	1881/644 n.s	25410/054 *	0.896 n.s	1756/750 **	34/828 *	180/771 **	7/771 n.s		
cultivar	1	3/0830 **	23772/346 **	16557/012 *	27.00 **	867 **	20/073 n.s	102/083 *	16/821 n.s		
Cultivation type	1	0/05775 n.s	5441/086 *	21341/397 *	24.083 **	363 *	91/025 **	36/750 n.s	47/571 **		
Cultivar × cultivation type	1	2/93783 **	64/473 n.s	3903/496 n.s	2.083 n.s	140/083 n.s	9/974 n.s	14/083 n.s	0/046 n.s		
Density	3	7/82416 **	32339/720 **	129863/277 **	1.833 n.s	41/028 n.s	25/876 n.s	53/639 n.s	10/386 n.s		
Density × cultivar	3	0/65125 *	2512/820 n.s	1435/920 n.s	0.0389 n.s	46/50 n.s	1/932 n.s	56/083 n.s	11/595 n.s		
Cultivation type × density	3	0/66515 *	5241/667 *	5610/889 n.s	1.250 n.s	103/389 n.s	40/133 *	32/306 n.s	37/478 **		
Density × cultivar × cultivation type	3	0/37694 n.s	650/713 n.s	1927/119 n.s	3.795 *	31/694 n.s	26/305 n.s	24/972 n.s	5/555 n.s		
Error	30	0/19283	1261/943	3259/464	0.651	69/194	9/636	19/815	6/272		
C.V	%	17/34	22/42	19/79	2.53	20.42	14.69	23.28	9.48		

Leaf dry weight

Green basil with mean of 180.68 g/m² had higher yield than purple basil with mean of 136.17 g/m². Means of 169.07 g/m² and 147.78 g/m² were maximum and minimum values for two-row and one-

row at leaf dry weight, respectively. Density of 100 plants per m² had the highest values for leaf dry weight and the lowest value was in 40 plants per m². Cross effects of cultivar, cultivation type and density showed that green basil in both one and two-row with

the compaction of 100 plants per m² had maximum yield for leaf dry weight.

Analysis of correlation coefficient showed positive relation between leaf and whole plant dry weight; this means, as leaf dry weight increases, whole plant dry weight does too.

Whole plant dry weight

Density on whole plant dry weight had significant effect at 1% level. Effects of cultivar and cultivation type on this feature were significant at 5% level. Green basil had higher whole plant dry weight than purple. Two-row cultivation allocated higher yield than one-row in whole plant dry weight. Results, also, showed that density of 100 and 40 plants per m² had maximum and minimum yields in this feature, respectively. Totally, triple effects of cultivar, cultivation type and density showed that green basil in one-row with 100 and 80 plants per m² and purple basil in two-row with the density of 100 plants per m² had the highest yield in whole plant dry weight. Therefore, green basil in two-row and 100 plants per m² recommend if cultivated in order to obtain maximum dry weight.

Number of branches

Results showed that green basil in both cultivation methods had the highest and purple basil in one-row cultivation had the lowest number of branches. Triple cross effect of cultivar, cultivation method and density showed that green basil in two-row cultivation with 80 plants per m² produces the highest number of branches.

Leaf number

Green basil in two-row method in densities of 40 and 60 plants per m² produced maximum leaf number. Purple basil with the same method and densities had minimum leaf number (Table 2).

Dry weight of other plant parts

Simple effects of cultivation method on dry weight of other plant parts were significant at 0.01. Cross effect of cultivation method and density on this feature was

significant at 0.05. Green basil in two-row cultivation method with 40 and 60 plants per m² had the highest dry weight of other plant parts and purple basil with densities of 40,60 and 80 plants had so. Coefficient correlation between characters showed that this character has no relation to others.

Plant height

Green basil in two-row cultivation with 100 plants per m² as well as purple basil in one-row with 100 plants per m² and in two rows with 80 and 100 plants per m² was the highest. Data showed that plant height has positive correlation with characters such as leaf number, spike length, biological yield and dry weight of leaves at 0.01 and with spike number in plant and number of branches at the level of 0.05. i.e. by increasing plant height, these characters increases.

Spike length

Green basil in two-row cultivation had the maximum length and purple basil in one-row cultivation had minimum spike length. Results also showed that green basil in two-row cultivation with the densities of 40 and 60 plants per m² had the highest length among the others.

Discussion

Literature review showed there are few reports on purple basil and cultivation types. Most of researches on basil focused on green cultivar; although purple cultivar is the same common as green in Iran. Furthermore, two-row cultivation is a new method in basil cultivation. We attempt to test yield parameters and growth characters for purple basil in comparison to green one. In medicinal and aromatic plants such as basil, fresh and dry weight for whole plant and leaves and yield have important role in plant production. Thus, we tried to investigate simple, double and triple effects of growth parameters in two cultivars and two cultivation types in different densities for obtaining maximum yield.

Whole plants dry weight increase when dry weight of different parts of the plant increases (Omidbaigi, 2000). In basil, vegetative growth continues despite

of beginning reproductive growth. Rashedmohassel and Nezami (1998) reported that apical growth was stopped in fennel at the first stage of flowering and lateral branches begin to develop.

Results obtained from correlation coefficient showed that number of lateral branches with number of leaves has positive relationship at 0.01 levels. This means that by increasing lateral branches in plant, number of leaves would be increased. This finding is similar to Simon (1995). By increasing density from 40 to 100 plants per m², dry weight will raise. Due to increased plant per unit of area, dry weight will increase in density of 100 plants per m². This is the same event that takes place in two-row cultivation of basil. These findings confirm the study of Jalilavand *et al.* (2006). Increasing density results in raising leaf dry weight and whole plant dry weight in the unit area. This is due to, however, in high densities whole plant and leaf dry weight will fall, but there are more plants per unit area, it causes rising in leaf dry and whole plant dry weight totally. Akbarinia *et al.* (2006) reported that plants in high densities compete for light, thus, it results in rising plant height. Our findings demonstrated that plant height increases when density increased 40 to 100 plants per m².

Results, also, showed that the highest level of characters such as number of spike and branches per plant and leaf index would seen in green basil with two-row cultivation by 40 plants per m². On the other hand, the lowest level of these characters observed in lowest density (40 plants per m²). It means that there is a reverse relationship between plant density and number of spike, number of branches and leaf index in these plants. In fact in high densities, values of these characters are lower in a single plant than plants grown in low densities, but due to high frequency of plants per unit area in high densities, it compensate and characters show higher levels in totally. In contrast, in low densities, despite of raised level of these characters in a plant, due to lower number of plants per unit area, number of spike, number of branches and leaf index in low density cannot compensate it.

Analysis of correlation coefficient between characters showed that spike length with number of branches and leaf number at 0.01 levels and with dry leaf weight at 0.05 levels have positive relationship. That is, by increasing spike length, number of branches and leaf number will increase. Results, also, showed that increasing density result in decreasing spike length in the plants. Effects of plant density on spike length have no significant effect. This finding is in agreement with the study of Jalilavand (2006).

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