



RESEARCH PAPER

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Effect of plant density in some basil cultivars on yield and radiation use efficiency

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Abstract

Basil is popular culinary herb and used as fresh and dried in Iranian and Mediterranean diet. Moreover, basil is used in traditional medicine and well-known flavoring principles. Nowadays consumption of this culinary herb increases due to its flavor and antioxidant activity. Therefore, optimizing biomass production is necessary. One of the agriculture practices that must be optimized for herb production is plant density and light use efficiency. The objective of this study was to evaluate the influence of plant density and cultivar on biomass production. Five different cultivars from different regions of Iran (Ardestan, Marvdasht, Mobarake, Kashan, Babol), with four plant densities, 500, 250, 100, 50 plant m⁻² were studied in the experimental greenhouse of horticulture department of Tehran university. The highest yield and light use efficiency obtained in Ardestan cultivar and 500 plants m⁻² density. In plants such as basil that yield is dependent on vegetative growth, plant density should be taken into account based on cultivar to obtain maximum use of light and obtain better yield.

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Introduction

Among various medicinal and culinary herbs, sweet basil is interested. Sweet basil (*Ocimum basilicum* L.) from Lamiaceae family is one of the most common herbs. It is native to Asia, and nowadays has cultivated all over the world (Simon *et al.*, 1999). Basil is widely used for its therapeutic properties, as well as for aromatic, culinary purposes, also consumed dry or fresh herb. Traditionally, basil has been used as a medicinal plant in the treatment of headaches, coughs, diarrhea, constipation, warts, worms and kidney malfunction (Khalid, 2006). In fact the extracts from fresh leaves and flowers can be used as aroma additives in food, pharmaceuticals and cosmetics. Moreover, essential oil of basil is known to possess antimicrobial, insecticidal activities and recently it has found to have in vivo anti malaria activity (Zheljzakov *et al.*, 2008). Several studies considered the essential oil composition in different basil varieties and compared them in relation to the characteristics of the essential oil (Grayer *et al.*, 1996). Essential oils content of basil are different, based on cultivars and agricultural practices (Carlo *et al.*, 2013). Basil essential oil contains high concentration of linalool and methyl chavicol. Basil is known to have strong antioxidant activity and contains phenolic compounds such as rosmarinic acid, chicoric acid and caffeic acid, these phenolic compounds and flavonoids are strong antioxidants (Javanmardi *et al.*, 2002). A key factor for successful crop production is the capacity to produce sufficient edible biomass within the lowest possible area, volume and energy inputs such as irradiance (Beaman *et al.*, 2009). In other report by (Oda *et al.*, 1989) they showed that daily light integral may be a key factor in edible biomass production of salad crops. In addition, there may be health issues related to irradiance capture by plants, research indicates that essential oil content in basil increases with greater irradiance, whereas the concentration of the principal component of the essential oil, methyl eugenol, decreased with ultra violet B treatment. Methyl eugenol is carcinogenic in large amounts and, therefore, a reduction in the concentration of this

compound with the increase in irradiance would be beneficial for human health (Nitz and Schnitzler, 2004). The production of edible biomass in herbaceous plants such as basil requires maintenance of vegetative tissues while delaying the development of reproductive tissues. Therefore, control of flowering in basil is important (Beaman *et al.*, 2009). Light is an important environmental factor affecting crop development and growth in plants. The amount of light reaching inside the canopy and absorbed by the plant changes with plant density. Most of the plant responses to shading are lower dry matter production, photosynthetic retention in the stem at the expense of root growth, bigger and thinner leaves (Francescangeli *et al.*, 2006). However, the effects of different light intensities caused by different plant densities have not been determined for basil.

In the absence of biotic and abiotic stresses, crop biomass accumulation depends on the quantity of PAR (photosynthesis active radiation) intercepted by the canopy (Kiniry *et al.*, 1989). Crop growth depends on the ability of canopy to capture PAR, water and nutrition's (Albrizio *et al.*, 2005), which is affected by the leaf area index (LAI) and canopy characters, and the conversion coefficient to biomass, the relationship between crop biomass and IPAR (intercepted PAR) has been termed RUE (radiation use efficiency; $g\ MJ^{-1}$) (Gifford *et al.*, 1984). Most of the research for optimizing plants densities and RUE are for cereals and maize and few studies reported RUE for leafy herbs. In leafy herbs, basil is high demanded crop specially for using as fresh for local markets and dried for spices. So, it is necessary to optimizing plant density for biomass production of this aromatic herb. The purpose of this study was to evaluate five local Iranian Basils with 4 plant densities in greenhouse condition to optimize best densities for planting basil in the greenhouse condition and quantify RUE for different plant densities to better understand of plant densities on RUE and yield.

Materials and methods

Growing condition and plant materials

This study was conducted in the greenhouse of

department of Horticulture, University of Tehran (35°50'07"N 51°00'37"E-karaj-Iran). Basil seeds were collected from farmers of some famous places for basil production; locations are Mobarake, Ardestan, Marvdasht, Kashan and Babol.

The basils are sown directly with four densities (500, 250, 100, 50 plant m⁻²) on winter of 2011 and harvested 80 days later. The soil was loamy clay with 3–5% organic matter. Prior to sowing, the soil was analyzed for available nutrients, and organic fertilizers were added also we add sands for optimizing our soil media for planting basils. During our experiment air temperature was 25-30 °C and radiation was 250 μmol m⁻² s⁻¹.

Crop characteristics and RUE at harvest time

Stem length, number of lateral branches, number of internodes, internodes length, number of leaves, length and width of leaves, fresh and dry weight of stem and leaves, leaf area (by leaf area meter, model Delta-T) United kingdom, were noted. For measuring leaves length and width, leaves from the third basal node on the plants were evaluated. RUE is determining yield divided by the quantity of intercepted solar radiation.

Experimental design and statistic analysis

The experiment design was completely randomized block design with factorial trial, each treatment was replicated three times. From each plot, three plants were collected for sampling. Analysis of variance (ANOVA) with a significant level of P < 0.05 was performed for comparing the cultivars and densities. When significant differences were observed Duncan test was applied using SAS 9.1 software package for Windows (SAS Institute Inc., 2003).

Results

Effect of cultivar on crop characteristics

In this study results showed that, Ardestan cultivar, compare to other cultivars had significant difference in crop characteristics and yield, this cultivar has the highest leaves number (Fig.1), stem length (Fig.2) and

leaf weight (Fig.3), yield (Fig.4) and LUE (Fig. 5). This cultivar producing maximum biomass production compare to others also, it is more acceptable for using as fresh herb compare to others.

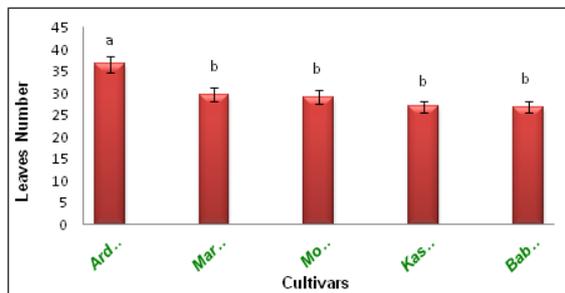


Fig. 1. Effect of cultivars on leaves number.

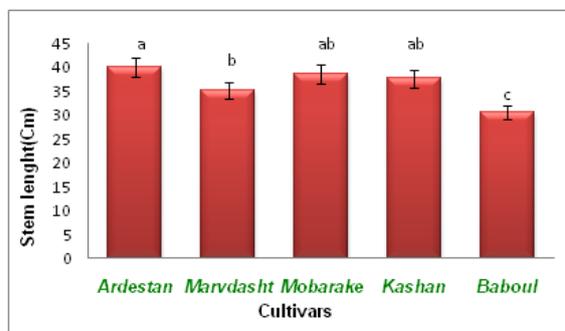


Fig. 2. Effect of cultivars on stem length.

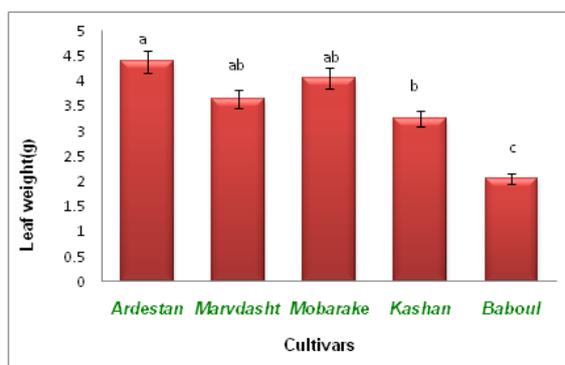


Fig. 3. Effect of cultivars on leaf weight.

Effect of density on crop characteristics

The highest lateral branches observed in 50 plants m⁻², although there wasn't significant difference between plant densities and cultivars. Number of lateral branches increase in multiple harvesting that cut the stem above the fist internode and allow plants to produce lateral branches. So, low density planting is recommended for multiple harvesting and high density is suggested for one times harvest. We didn't see any significant differences in leaf area, number of

internodes, length and width of leaves and leaves number under different plant density. These show that these characteristics are based on genetics more than agricultural practices.

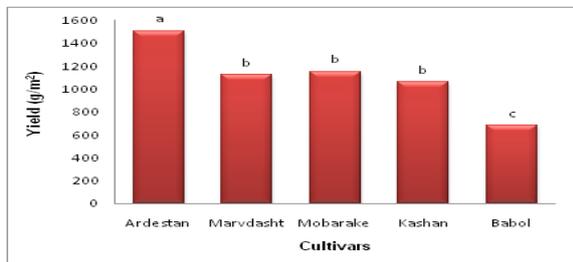


Fig. 4. Effect of cultivar on yield.

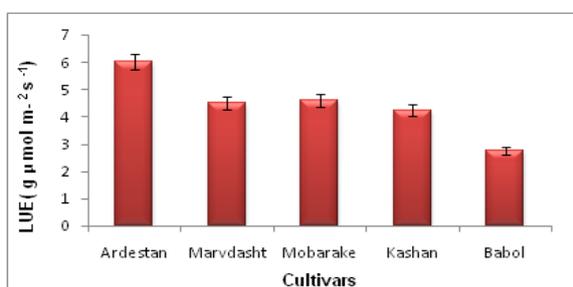


Fig. 5. Effect of cultivar on light use efficiency.

Results of density showed that planting 500 plants m⁻² showed the highest stem length compare to other densities. Moreover, yield and LUE in 500 plants m⁻² was the highest compare to other cultivars and by decreasing plant densities, yield and LUE decrease (Fig. 6, 7). These results showed that in high density planting because the leaves area didn't effect, both yield and LUE increased and we managed better use of energy and land by this planting pattern. In the report by (Callan *et al.*, 2007), they show that under lower density the oil consistent quality of dill increases while, in the high density herbaceous characteristics and yield increase. In our results we didn't measure oil consistent of basils under different density while in high density we had more yield. In our experiment by increasing plant density, radiation use efficiency increases, this is also reported by (Ruiz and Bertero, 2008). In their report by increasing leaf area and photosynthetic activity the amount of LUE increase, and this increasing continued until senescence of leaves. In our experiment we harvested basils only one time and we didn't allow the plants to produce sub benches in following harvests, so in this

condition, for having better yield and use of land, water and light we recommend high plant density. On the other hand, health issue of basils must be considered by increasing plant density. In addition, suitable cultivar must be chose for basil production, in our experiment each cultivar had different shape and suitable for different purpose, for instance cultivar babol had super flavor and can be used for cosmetic and pharmaceutical purpose while, Ardestan cultivar can be use as fresh and dried herb.

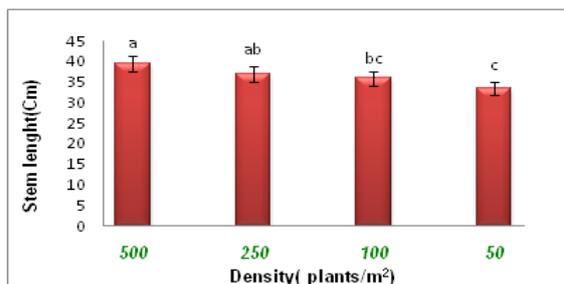


Fig. 6. Effect of plant density on stem length.

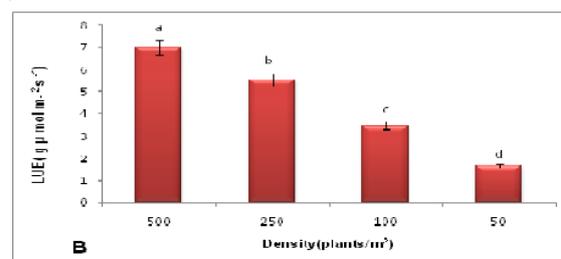
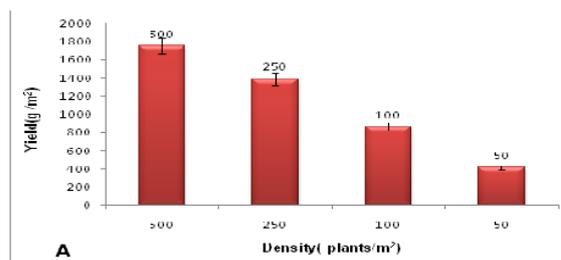


Fig. 7a . Effect of plant density on yield and 7b . Effect of plant density on LUE.

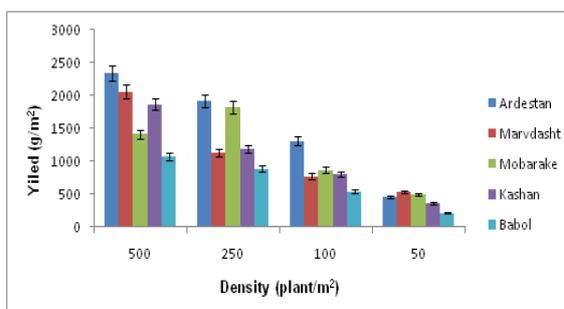


Fig. 8. Interaction effect of cultivar and plant densities on yield

Conclusion

In plants such as basil that yield is depend on vegetative growth, optimal plant density based on cultivar is necessary to obtain maximum use of light for having highest biomass. Moreover, other factors such as water availability, nutrition availability in soil, temperature, harvest time and harvest method must be considered in basil production.

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