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Hamed Mabudi Bilasvar
Department of Plant Ecophysiology, Faculty of Agriculture, University of Tabriz, Tabriz. Iran

Saeid Zehtab Salmasi
Department of Plant Ecophysiology, Faculty of Agriculture, University of Tabriz, Tabriz. Iran

Correspondence
Hamed Mabudi Bilasvar
Department of Plant Ecophysiology, Faculty of Agriculture, University of Tabriz, Tabriz. Iran

Essential oil yield and some morphological characteristics of sweet basil cultivars affected by different intercropping patterns with corn

Hamed Mabudi Bilasvar, Saeid Zehtab Salmasi

Abstract
An experiment on randomized complete block design with three replications were carried out to investigate the impact of different intercropping systems (sweet basil cultivars; Mobarake and Italian large leaf sole cropping (40 plants m^{-2}) and the additive intercropping of sweet basil cultivars + corn (20 + 8, 30 + 8 and 40 + 8 plants m^{-2}) on some sweet basil cultivars morphological traits and essential oil yield in 2014. Results showed that maximum plant height, number of leaf and lateral branch, plant dry weight and essential oil yield of both Mobarake and Italian large leaf were recorded under sole cropping pattern. With increasing density of sweet basil from 20 up to 40 plants m^{-2} in intercropping with corn, plant height, number of leaf and lateral branch in both Mobarake and Italian large leaf cultivars decreased. However, plant dry weight and essential oil yield slightly increased with increasing density of sweet basil from 20 up to 40 plants m^{-2}. Although, corn intercropping with sweet basil cultivars had reducing effects on morphological characteristics and also essential oil yield of sweet basil plants, but in additive intercropping patterns as a drug forage system we can use these sweet basil cultivars.

Keywords: corn, drug forage essential oil, intercropping, sweet basil

1. Introduction
Intercropping may be a useful strategy to grow crops simultaneously, offering to improve resource utilization such as solar radiation, nutrients and water during growth and development. This is also an important method for sustainable crop production, particularly when inputs are limited (Agegnehu *et al*., 2006) [2].
Plant mixtures can be formed by adding together the plant populations used in the pure stands (Agboola and Fayemi, 1971) [1]. This means that in such additive intercropping systems the total plant population of the mixtures is doubled when two crops are intercropped in this manner (Ebwongu *et al*., 2001) [6]. In other words, an inherent feature of additive intercropping is that the total plant population of the mixture is greater than that of the pure stands, which may contribute to its yield advantage (Willey and Osiru, 1972) [15].
Medicinal plants are looked upon not only as a source of affordable health care products but also as a source of income. There is a growing demand for plant based medicines, health products, essential oils, fragrances, cosmetics and natural aroma chemicals in the national and international markets (Sujatha and Bhat, 2010) [13]. Cultivation of medicinal plants has several advantages like higher net returns per unit area, low incidence of pests and diseases, improvement of degraded and marginal soils, longer shelf life of end products and foreign exchange earning potential (Rao *et al*., 2004) [12]. Sweet basil (*Ocimum basilicum* L.) belong to the family Lamiaceae is an important medicinal plant and culinary herb which is used in treatment of headaches, diarrhea, coughs, warts, worms and kidney malfunctions (Bais *et al*., 2002; Rai *et al*., 2004) [5, 11]. Corn is used for human food, livestock feed and as a source of industrial raw material for the production of oil, alcohol and starch (Muoneke *et al*., 2007) [8]. This plant is used in different intercropping systems, but the effect of different intercropping systems between sweet basil cultivars and corn plants is unclear. Therefore, this research was aimed to evaluate the effects of different intercropping systems on some morphological characteristic and essential oil yield of sweet basil cultivars in intercropping with corn.

2. Materials and methods
In order to evaluate the effects of different intercropping systems (sweet basil cultivars; Mobarake and Italian large leaf sole cropping (40 plants m^{-2}) and the additive intercropping of

sweet basil cultivars + corn (20 + 8, 30 + 8 and 40 + 8 plants m^{-2}) on some morphological traits and essential oil yield of sweet basil cultivars, an experiment using randomized complete block design with three replications was conducted in 2014 at the University of Tabriz, Iran (38°5N, 46°E).

Seeds of both sweet basil cultivars and corn plants were treated with 2 g kg^{-1} benomyl and sown in a sandy loam soil. Each plot consisted of 6 rows of 2.5 m length, spaced 50 cm apart. All plots were irrigated immediately after sowing. Subsequent irrigations were carried out every 7 days. Hand weeding of the experimental area was performed as required.

At flowering stage of sweet basil cultivars, plants of 1 m^2 in each plot were harvested. Plant height, number of leaf and lateral branch were measured. Then, plants dried in an oven at 75 °C for 48 h and dry weight was determined.

Air dried sweet basil plants (leaf + stem + flower) were crushed at 20 g by electric grinder and suspended in 500 ml distilled water. Ground mass was subjected to hydro-distillation using Clevenger's apparatus, After 4 h, the essential oils were collected. Then essential oil percentage and yield (g m^{-2}) was determined.

All the data were analyzed on the basis of experimental design, using SAS software. The means of each trait were compared according to Duncan multiple range test at $P \leq 0.05$.

3. Results and discussion

The effects of different intercropping systems on plant height, leaf number, lateral branch number, plant dry weight and essential oil yield was significant (Table 1).

Tab 1: Analysis of variance for some morphological traits and essential oil yield of sweet basil cultivars in response to different intercropping patterns with corn

		MS				
Source	**df**	**Plant height**	**Leaf number**	**Lateral branch**	**Plant dry yield**	**Essential oil yield**
replication	2	5.05	2.32	0.61	8610.16	0.37
Intercropping patterns	7	91.16*	3428.91**	19.05**	746060.07**	29.61**
error	14	23.40	30.97	0.37	8727.78	0.43
C.V%		12.05	8.55	11.76	12.18	11.82

*, **: Significant at $p \leq 0.05$ and $p \leq 0.01$, respectively

Both of cultivars had low height under different intercropping systems. There was no significant difference in plant height between different intercropping patterns and between both cultivars. However, plants of both cultivars had slightly more height at S20/C8, compared with other patterns. Maximum height in both of Mobarake and Italian large leaf cultivars was recorded under sole cropping patterns (Figure 1). Olufajo (1992) [10] and O' Callaghan *et al*. (1994) [9] indicated that shading by the taller plants in intercropping systems could reduce the photosynthetic rate of the lower growing plants and thereby reduce growth of these plants. In other results, (Thwala and Ossom, 2004) [14] did not find any significant difference in plant height between mono cropping and intercropping of maize with sugar bean and ground nuts. In this study, it was observed that maize plant population density had no effect on sweet basil ecotypes height. But, under sole cropping pattern sweet basil plants have competition with each other and height of plants was increased. Hunt *et al*. (1977) [7] observed increase in plant height and internodes length with increasing plant population density to competition for light.

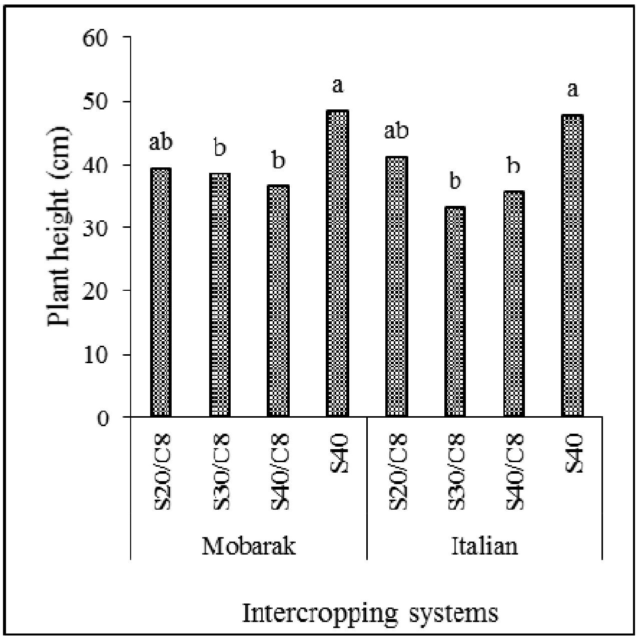

Fig 1: Plant height of sweet basil cultivars (Mobarake and Italian large leaf) in response to different intercropping systems with corn

With increasing density of sweet basil plants from 20 to 40 in intercropping with corn, number of leaf and lateral branch in both Mobarake and Italian large leaf cultivars decreased. This reduction, under S30/C8 and S40/C8 for leaf number of Mobarake cultivar and for number of lateral branch in both cultivars were significantly similar. Both cultivars under sole cropping pattern had significantly more leaf and lateral branch number. Maximum number of leaf and lateral branch in Mobarake were more than that of Italian large leaf cultivar (Figure 2a, b). As, corn plants are taller than sweet basil cultivars, reduction in light penetration into canopy was caused sweet basil plants had lower photosynthesis. Thus, in this condition plants don't have enough assimilate to produce leaf and lateral stems. Alizade *et al*., (2009) [4] reported that the lateral stem of *Ocimum basilicum* and *Phaseolus vulgaris* decreased in intercropping system.

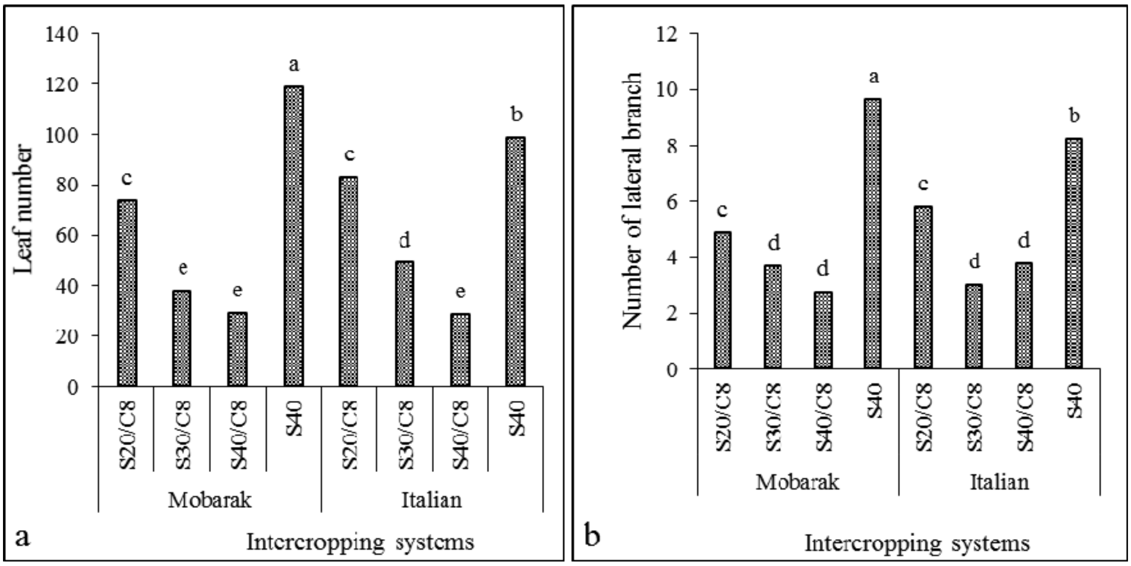

Fig 2: Number of leaf (a) and lateral branch (b) of sweet basil cultivars (Mobarake and Italian large leaf) in response to different intercropping systems with corn

Plant dry weight and essential oil yield of both Mobarake and Italian large leaf slightly improved with increasing sweet basil plants density with intercropping with corn. However, in most case there was no significant difference in plant dry weight and essential oil yield between different intercropping systems. The highest plant dry weight and essential oil yield were recorded under sole cropping pattern. Maximum essential oil yield of Mobarake cultivar was more than that of Italian large leaf cultivar (Figure 3a, b). Improvement in plant dry weight of plants under sole cropping pattern associated by increase in plant height (Figure 1), number of leaf and lateral stem (Figure 2 a, b) in both sweet basil cultivars. This is suggesting that, the competition of corn with sweet basil plants for light resulted in the reduction in dry matter formation. Hunt *et al*. (1977) [7] reported that under condition of low photosynthesis caused by low light levels, the supply of carbohydrate is low and the proportion of dry matter is decreased. Plant dry weight strongly influenced essential oil yield of plant. Similarly result was reported by Aharizad *et al*. (2013) [3] on *Lemon balm.*

Although, corn intercropping with sweet basil cultivars had reducing effects on morphological characteristics and also essential oil yield of sweet basil plants, but it seems in additive intercropping patterns as a drug forage system we can use these sweet basil cultivars.

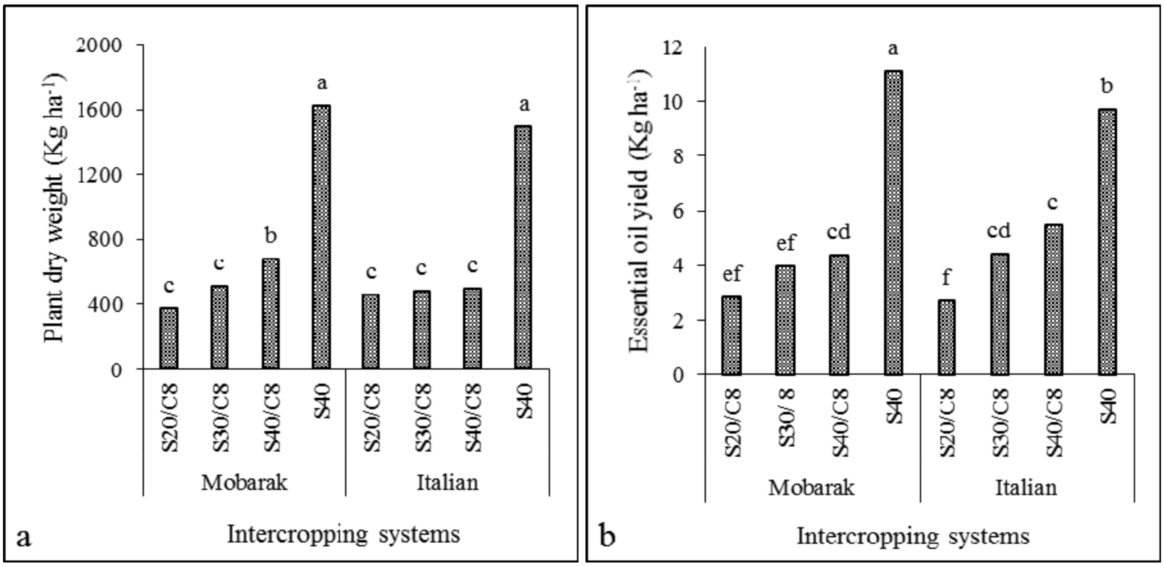

Fig 3: Plant dry weight (a) and essential oil yield (b) of sweet basil cultivars (Mobarake and Italian large leaf) in response to different intercropping systems with corn

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