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ORIGINAL ARTICLE

Cropping Pattern and Time of Harvest Effects on Essential Oil Content of two Sweet Basil cultivars in Intercropping with Corn

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ABSTRACT
A split plot experiment (using RCB design) with three replications was conducted during 2014-2015. In this study, different intercropping systems including sweet basil sole cropping (40 plants m^{-2}); corn sole cropping (8 plant m^{-2}); the additive intercropping of sweet basil (S.b) cultivars (Mubarake (M) and Italian Large Leaf (I)) + corn (20 S.b M or I + 8 C, 30 S.b M or I + 8 C, 40 S.b M or I + 8 C) were located in main plots and time of harvest were allocated to sub plots. Results indicated that fresh and dry weight of sweet basil in sole cropping was more than different intercropping patterns. Fresh and dry weight of Iranian cultivar (Mubarake) was more than Italian Large Leaf under all intercropping systems. In both cultivars fresh and dry weight in second time of harvest was higher than that of first one. Intercropping system was caused essential oil of sweet basil cultivars increased, compared with sole cropping. Essential oil percentage of Mubarake was more at first time of harvest, but this trait in Italian Large Leaf cultivar was more in second time of harvest. Essential oil yield of both cultivars similar to fresh weight of plant was higher under sole cropping pattern. It is concluded that different intercropping patterns of sweet basil and corn can enhance the essential oil percentage of sweet basil cultivars and also time of harvest is important factor for producing of essential oil from this medicinal plant.
***Keywords:** corn, essential oil, intercropping, sweet basil, time of harvest*

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INTRODUCTION

Medicinal plants play major roles in human health services worldwide. Many people in both developing and developed countries are turning to herbal medicine [1].Sweet basil (*Ocimum basilicum* L.) belong to the family Lamiaceae is an annual, herbaceous, white to purple flowering plant, 20-60 cm tall, that originated in Iran and India. Sweet basil (2n = 48), is an important medicinal plant and culinary herb which is used in treatment of headaches, diarrhea, coughs, warts, worms and kidney malfunctions [2,3]. Secondary metabolites from *Ocimum* species possess exceptional biological activity and have antioxidant [4] and antimicrobial [5], bactericidal [6].

Maize (*Zea mays* L.) is the third most important cereal crop in the world. Maize is grown all over the world in a wide range of climatic conditions. This plant features prominently in intercropping systems involving legume and non-legume crops such as soybean, cowpea, cassava, yam, etc. Maize is used for human food, livestock feed and as a source of industrial raw material for the production of oil, alcohol and starch [7].

Intercropping, the simultaneous growing of two or more species in the same field for a significant period of their growth is known to increase yield compared to sole crops. This method allows lower inputs through reduced fertilizer and pesticide requirements, thus minimizing environmental impacts of agriculture [8]. Intercropping is a widespread practice used in many areas of the world that may

minimize adverse effects of biotic and abiotic factors, protect soil against erosion, improve the use of limited resources, increase stability of yield and provide higher outputs [9].
Intercropping is a way to increase diversity in an agricultural ecosystem. In addition, by using the intercropping system, the ecological balance, a better utilization of resources, higher quantity and quality of products, and less damage by pests and diseases are well achieved. Those systems, which are often without synthetic input and are based on an integrated management of local natural resources, theoretically offer numerous ecological advantages. Additionally, medicinal forage (intercropping of forage and medicinal crops) is considered as alternative forage sources to prevent contamination from diseases and improve growth and development in livestock [10]. It is not clear whether different intercropping systems between corn and sweet basil plant can affect essential oil percentage and yield of this medicinal plant, thus, our study was aimed to investigate the effects of different cropping pattern and time of harvest on essential oil content of two sweet basil cultivars in intercropping with corn.

MATERIALS AND METHODS

A split plot experiment using randomized complete blocks design with three replications was conducted during 2014-2015 at the Research Farm of the Faculty of Agriculture, University of Tabriz, Iran (38°5N, 46°E). In this study, different intercropping systems including: sweet basil sole cropping (40 plants m^{-2}); corn sole cropping (8 plant m^{-2}); the additive intercropping of sweet basil (S.b) cultivars(Mubarake (M) and Italian Large Leaf (I) + corn (20 S.b M or I + 8 C, 30 S.b M or I + 8 C, 40 S.b M or I + 8 C) were located in main plots and time of harvest (TH) for sweet basil plants including: 94 (TH1) and 124 (TH2) days after sowing (DAS) were allocated to sub plots. Mubarake and Italian large leaf cultivars have been provided by Pakan Bazr Isfahan Company and EDEN Brothers Company, respectively.
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 (94 DAS) of sweet basil, the first harvest was conducted and the second harvest of sweet basil plants was carried out 30 days after first stage (124 DAS). In both stages, plants of 1 m^2 in each plots were harvested. Fresh weight of harvested plants speedy measured. Then, dry weight of dried plants in an oven at 72°C for 48 h 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 MCTAT-C and SAS software. The means of each trait were compared according to Duncan multiple range test at P≤0.05.

RESULTS AND DISCUSSION

Fresh weight, dry weight and essential oil yield of sweet basil plants significantly affected by intercropping patterns, times of harvest and interactions between these treats. The effect of different intercropping patterns and also interaction between intercropping patterns × times of harvest on essential oil were significant (Tab 1).

Tab 1:Analysis of variance for fresh and dry weight, essential oil percentage and yield of sweet basil cultivars in response to different intercropping patterns with corn and times of harvest.

Source	Mean squares				
	df	FW	DW	EO	EO yield
Replication	2	1575.09	43.18	0.019	0.0042
Intercropping patterns (I)	7	147687.27**	3728.22**	0.169*	0.165**
Error	14	860.60	43.73	0.024	0.002
Time of harvest (T)	1	90888.91**	1514.25**	0.014	0.098**
I×T	7	2293.05*	45.97*	0.051*	0.0065*
Error	16	845.91	16.17	0.018	0.0018
C.V%		11.45	10.49	17.42	15.15

*, **: Significant at p≤0.05 and p≤0.01, respectively
FW, DW and EO; fresh weight, dry weight and essential oil, respectively

Both cultivars of sweet basil had the maximum fresh weight under sole cropping condition in comparison with different intercropping patterns with corn at both times of harvest. Mubarake cultivar at intercropping (S.b.M40+C8) had more fresh weight, compared with other intercropping patterns at both times of harvest. In contrast, at both times of harvest there was no significant difference in fresh weight of

Italian Large Leaf cultivar under all intercropping patterns? In general, fresh weight of both cultivars of sweet basil in second time of harvest was more than first time of harvest under all intercropping patterns and sole cropping condition. Maximum fresh weight of Mubarake at both time of harvest was more than that of Italian Large Leaf cultivar (Fig 1).

Similar to fresh weight, dry weight of both sweet basil cultivars (Mubarake and Italian Large Leaf) under sole cropping was more than different intercropping patterns. At first time of harvest, with increasing Mubarake density from 20 up to 40, dry weight of this medicinal plant increased. But, there was no significant difference between day weights of Mubarake cultivar at second time of harvest and also, at both time of harvest for Italian large Leafcultivar. Dry weight of sweet basil cultivars in second time of harvest was more than that of the first time of harvest under all intercropping patterns and sole cropping (Fig 2). Fresh and dry weight reduction in intercropped sweet basil plants could be due to shading by the taller corn plants. Olufajo [11]and O' Callaghan *et al*[12]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. Sweet basil plants in sole cropping conditions obtain more light and this increased photosynthesis and growth of these plants. Boroomand *et al*.[13] and Gill *et al*.[14]mentioned that by increasing of density, the umbels per plant decreased. This results is agree with our results which at different intercropping systems with increasing sweet basil density, plant fresh and dry weight were decreased (Fig 1 and 2). Similarly results reported for dill and fenugreek by Shokati and Zehtab Salmasi [15].

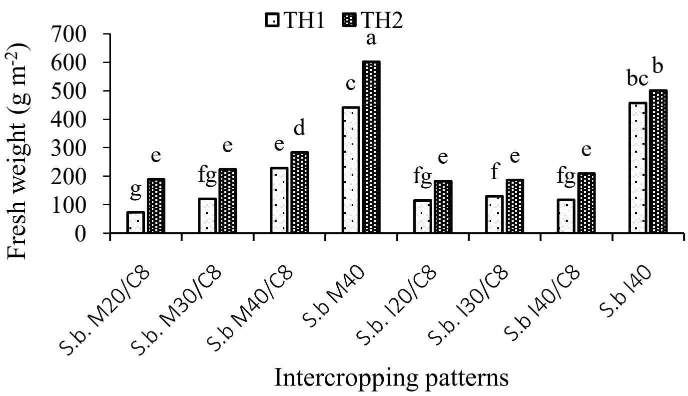

Fig 1: Fresh weight (FW) of sweet basil cultivars in response to different intercropping patterns with corn and times of harvest.

S.b.M/C and S.b.I/C: Mubarake cultivar of sweet basil + corn and Italian Large Leaf cultivar of sweet basil + corn, respectively

TH1 and TH2: Time harvesting of sweet basil plants at 94 and 124 DAS, respectively

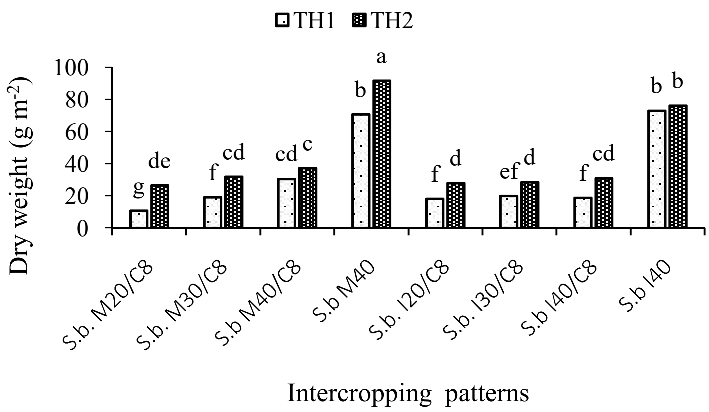

Fig 2: Dry weight (DW) of sweet basil cultivars in response to different intercropping patterns with corn and times of harvest.

S.b.M/C and S.b.I/C: Mubarak cultivars of sweet basil + corn and Italian large leaf cultivar of sweet basil + corn, respectively

TH1 and TH2: Time harvesting of sweet basil plants at 94 and 124 DAS, respectively

Essential oil of Mubarake cultivar in first time of harvest decreased with increasing of sweet basil plants density from 20 up to 40 m^{-2}. But, essential oil of this cultivar under different intercropping patterns with corn was not significant. Mubarake cultivar under sole cropping condition had lower EO than that of different intercropping patterns. The essential oil of Italian Large Leaf cultivar with increasing plant density at both times of harvest increased. However, this increasing at second time of harvest was more than first time of harvest. Intercropping pattern of S.b.I 20+8C in second time of harvest had lower essential oil in comparison with first time of harvest, but the second time of harvest had more essential oil in other intercropping patterns and also sole cropping. This advantage in essential oil percentage in different intercropping patterns is probably resulted from different growth habits and morphological characteristics of the intercropped plants, allowing more efficient use of resources, i.e., water, nutrients and radiation [16]. The highest sweet basil/corn essential oil percentage under intercropping was due to the least population of weeds and less inter-specific and intra-specific competition as compared with sole cropping systems.
Essential oil yield of sweet basil plants in both cultivars under sole cropping condition was more than that of different intercropping patterns. In both cultivars, essential oil yield in second time of harvest was higher in comparison with first time of harvest. Intercropping pattern of S.b.M 20+ 8C had slightly low essential oil yield, compared with other intercropping patterns. With increasing Italian Large Leaf cultivar density, especially under second time of harvest essential oil yield was also increased. Increasing in essential oil yield of sweet basil plants under sole cropping condition was associated with increasing fresh and dry weight of plants under this condition. The differences in essential oil percentage (Fig 3) and yield (Fig 4) between the two varieties in the early season could be attributed to the inherent varietal characteristics as also reported by Udealor [17] and Ano [18]. According to Udealor [17], different varieties of a particular crop respond differently to intercropping. Putievsky *et al.*[19]also noted that essential oil content of oregano (*Origanum vulgare*) was higher in full bloom stage than in the stage of early flowering. In other research Mirza *et al.*[20]indicated that the highest percentage of essential oil (2.8%) of *Mentha piperita* was recorded in full flowering stage.

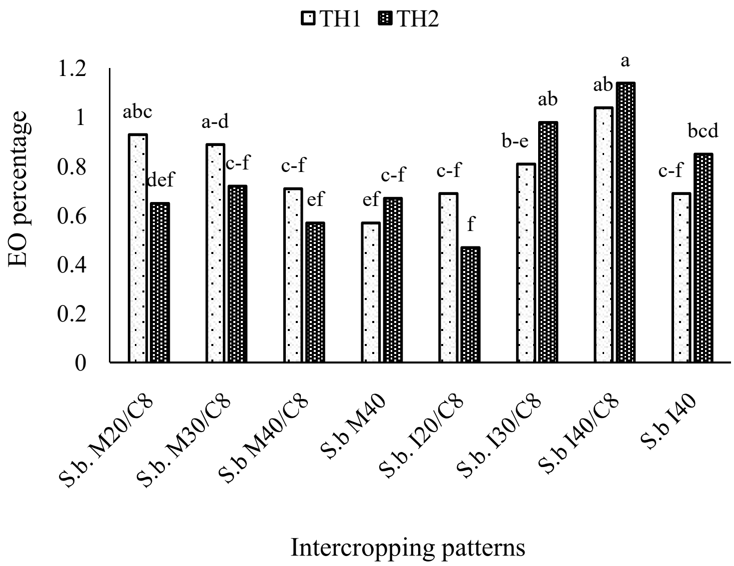

Fig 3: Essential oil (EO) of sweet basil cultivars in response to different intercropping patterns with corn and times of harvest.

S.b.M/C and S.b.I/C: Mubarak cultivars of sweet basil + corn and Italian large leaf cultivar of sweet basil + corn, respectively

TH1 and TH2: Time harvesting of sweet basil plants at 94 and 124 DAS, respectively

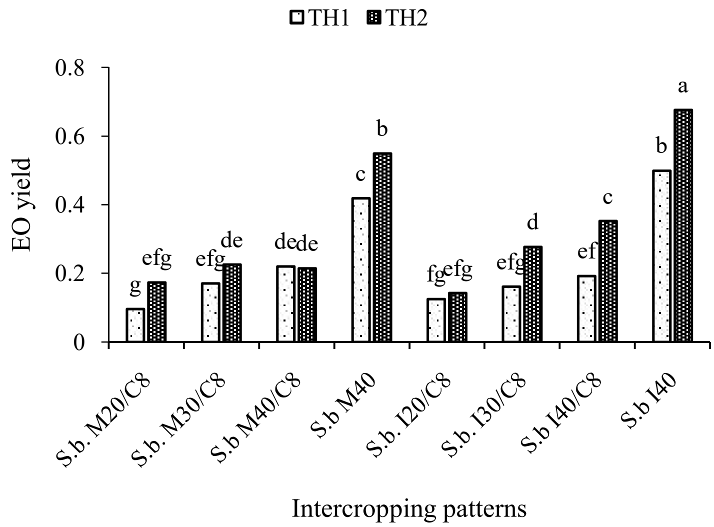

Fig 4: Essential oil (EO) yield of sweet basil cultivars in response to different intercropping patterns with corn and times of harvest.

S.b.M/C and S.b.I/C: Mubarak cultivarsof sweet basil + corn and Italian large leaf cultivar of sweet basil + corn, respectively

TH1 and TH2: Time harvesting of sweet basil plants at 94 and 124 DAS, respectively

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