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Essential oil production of dill affected by different intercropping patterns with berseem clover and harvesting times

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Abstract

Intercropping is the practice of producing multiple crops in a given space. In this research berseem clover and dill were intercropped at different additive series (100:25, 100:50 and 100:75) at the Research Farm of the Faculty of Agriculture, University of Tabriz, Iran. Field experiment was arranged as split plot based on randomized complete block design with three replicates. Dill umbels were harvested at flowering, dough development and complete ripening stages. Results showed that among harvesting times, dough development stage and among intercropping patterns, 100:50 treatment had the highest essential oil percentage, essential oil yield and harvest index of essential oil. Berseem clover as a forage and legume crop promotes dill essential oil production and could be an effective plant in intercropping systems with essential oil bearing medicinal plants such as dill.

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Introduction

Dill (*Anethum graveolens* L.) is an annual and sometimes biennial herb of the family Apiaceae, which is native to south-west Asia or south-east Europe, and has been cultivated since ancient times (Bailer *et al.,* 2001). The major active components of *A. graveolens* are flavonoids, phenolic compounds and essential oil (Amin and Sleem, 2007). Many studies were interested in the chemical composition of essential oil of *A. graveolens*, such as its antibacterial (Delaquis *et al.,* 2002; Jirovetz *et al.,* 2003; Rafii and Shahverdi, 2006), antifungal activity (Tian *et al.,* 2012), insecticidal properties (Chaubey, 2007; Seo *et al.,* 2009) and as an inhibitor of sprouting in stored potatoes (Zehtab-Salmasi *et al.,* 2006). Carrubba *et al.*, (2008) indicated that the presence of dill exerted residue in the soil had a significant effect on fennel seed yield at following years.

Berseem or Egyptian clover is an annual legume that is a vine with climbing growth habit, great productivity due to its high growth rate and good fodder recovery after cutting, and high levels of CP and nitrogen fixation. It is well adapted to a range of environments and is usually grown in the Mediterranean, central European, and southeast Asian countries for forage production (Williams *et al.,* 1990; Sardana and Narwal, 2000; Iannucci, 2001; El-Bably, 2002; De Santis *et al.,* 2004).

Plant mixtures can be formed by adding together the plant populations used in the pure stands (Agboola and Fayemi, 1971). 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). 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).

The biosynthesis of secondary metabolites, although controlled genetically, it is strongly affected by environmental factors, and also by agronomic conditions, harvesting time and the type of processing (Miguel *et al.,* 2004). One of the most important characteristics of oil essential accumulation is its dependence on the developmental stage of the plant per se as well as its concerned part (Sangwan *et al.,* 2001).

Some further interest in the potential role of medicinal and aromatic plants in intercropping systems has arisen from the widespread trend toward the cultivation of these plants. Nitrogen fixation by some plants may improve essential oil yield of medicinal plants in intercropping. Thus, this research was undertaken to evaluate the influence of berseem clover and vetch intercropping on essence production of dill.

Materials and methods

Field conditions and treatments

The field experiment was conducted at the Research Farm of the Faculty of Agriculture, University of Tabriz, Iran (38°5N, 46°E) at 2013. The experiment was arranged as split plot on the basis of randomized complete block design with three replicates. In this study dill (*Anethum graveolens* L.) and berseem clover (*Trifolium alexandrinum*) intercropped at different additive series (100:25, 100:50 and 100:75). The main and secondary crops were berseem clover and dill, respectively. As dill seeds are sensitive to seed bed conditions, therefore soft and smooth seed bed prepared and covered by thin layer of sand silt. Each plot consisted of 10 rows and seeds were sown at about 1-2 cm deep. Optimum densities for dill and berseem clover were considered as 100 and 500 plant/m², respectively. Seeds were treated with Benomyl at a rate of 2 g/kg before sowing. Weeds were controlled by hand during crop growth and development as required.

Data collection

Dill umbels were harvested at flowering, dough development and complete ripening stages. At each stage, 10 plants were harvested from each plot and the umbels were separated and dried. Then, dry umbels were distilled with 500 ml water and hydro-distillation was continued for 3 hours, using a Clevenger-type apparatus.

Statistical analysis

All data were analyzed using MSTAT-C statistical package (MSTAT, 1993). Means of each trait were compared according to Duncan multiple range test at p≤0.05.

Results and discussion

Analysis of variance of the data showed that the effect of different intercropping patterns (main factor), harvesting times (secondary factor), and their interaction were significant on essential oil percentage, essential oil yield and harvest index of essential oil (Table 1). In most of treatments intercropped dill plants produced a significantly higher amount of essential oil compared to monocultured plants (Table 2). It seems that nitrogen fixation by berseem clover helped dill plants to improve essence production. Similarly, Maffei and Mucciarelli, (2003) relived that in peppermint/soybean strip intercropping, essential oil content increased up to 50% and quality of essential oil improved.

Table 1. Analysis of variance of the data for essential oil percentage, yield and harvest index of dill at different harvesting times and intercropping patterns with vetch.

		Mean squares		
Source	df	Essential oil percentage	Essential oil yield	Essential oil harvest index
Replication	2	0.006	0.105	0.019
Intercropping patterns (I)	3	0.271*	0.859**	0.139**
Error (I)	6	0.030	0.073	0.008
Harvest time (T)	2	8.616**	36.121**	4.996**
I×T	6	0.336**	0.873**	0.136**
Error (T)	16	0.039	0.131	0.024
Total	35			
C.V%		14.88	21.09	24.32

*'** Significant at P≤0.05 and P≤0.01, respectively.

Table 1

At flowering stage the highest essential oil percentage (0.746%), essential oil yield (0.362g\m²) and harvest index of essential oil (0.135%) were obtained from sole dill treatment. At dough development stage, 100:50 treatment had the highest essential oil percentage (2.43%). Also in this stage the highest yield and harvest index of essential oil were obtained from 100:50 treatment. At complete ripening stage, the highest and lowest essential oil percentage recorded for 100:50 and sole dill treatments, respectively. As well as in this stage highest yield and harvest index of essential oil were obtained from 100:25 treatment (Table 2).

Table 2

Essential oil production at flowering stage was lower than that at dough development and maturity stages (Table 2). In contrast, Yoshida and Sawasaki, (1978) found that the maximum clary sage oil content was obtained at the end of the blossom period. Putievsky *et al.*, (1988) 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.*, (2011) indicated that the highest percentage of essential oil (2.8%) of *Mentha piperita* was recorded in full flowering stage, while *Salvia officinalis* had the highest percentage of essential oil (3%) in early flowering stage.

The highest essential oil percentage, yield and harvest index were recorded for dough development stage, followed by maturity stage (Table 2). Similarly, Telci *et al.*, (2006) showed that 20 days after flowering of

Coriandrum sativum maximum essential oil content achieved. Callan *et al.*, (2007) reported the highest oil yields of dill were obtained when most of the fruits on primary umbels were pigmented but had not become dry and fully mature. Aidi Wannes *et al.*, (2009) indicated that the highest fruit essential oil of *Myrtus communis* was obtained 60 days after flowering stage. Arif *et al.*, (2010) in sea buckthorn berries study reported that essential oil content increased by fruit maturity.

Table 2. Mean of the essential oil percentage, essential oil yield and essential oil harvest index of dill for harvesting times and intercropping patterns with vetch.

		Characters		
Harvesting time	Treatment	Essential oil percentage (%)	Essential oilyield (g\m^2)	Essential oil harvest index (%)
Flowering stage	100:25	0.307 f	0.106 f	0.043 e
	100:50	0.295 f	0.105 f	0.042 e
	100:75	0.342 f	0.106 f	0.045 e
	Sole dill	0.746 e	0.362 ef	0.135 e
dough development stage	100:25	2.185 ab	3.087 b	1.081 b
	100:50	2.43 a	4.57 a	1.678 a
	100:75	2.218 ab	3.946 a	1.58 a
	Sole dill	1.562 cd	2.764 b	1.021 b
Full ripening	100:25	1.613 cd	1.844 c	0.658 c
	100:50	1.873 bc	1.589 c	0.599 cd
	100:75	1.414 d	1.218 cd	0.511 cd
	Sole dill	1.026 e	0.879 de	0.325 de

Different letters in each column indicate significant difference at $p \leq 0.05$.

Finally, Present study suggests that harvesting time (flowering, dough development and complete ripening stages) and intercropping patterns had significant effect on essential oil production of dill; therefore these two factors important in essential oil production of Aromatic Plants. In this research the best harvesting time and intercropping patterns were dough development stage and 100:50 treatment, respectively. Also it could be suggested that intercropping of dill with nitrogen fixing plants such as vetch can enhance essential oil production per unit area.

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