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Influence of Compost and Biofertilizer on yield and essential oil of dill (*Anethum graveolens* L.)

Farnaz Shahmohammadi[1] , Mohammad Taghi Darzi[1]*, Mohammadreza Haj Seyed Hadi[1]

[1] Faculty of Agriculture, Department of Agronomy, Roudehen Branch, Islamic Azad University, Roudehen , Iran

Abstract
In order to study the influence of compost and biofertilizer on yield and essential oil of dill (*Anethum graveolens* L.), an experiment was conducted as factorial experiment in the base of randomized complete blocks design with eight treatments and three replications at research field of Agriculture Company of Ran in Firouzkuh of Iran in 2012. The factors were compost in four levels (0, 5, 10 and 15 ton/ha) and biofertilizer, *mixture of Azotobacter chroococcum* and *Azospirillum lipoferum* in two levels (non-inoculated and inoculated seeds). The present results have shown that compost had significant effects on evaluated traits except essential oil content, as the highest seed yield and essential oil yield after using 10 ton/ha compost and the maximum biological yield after applying 15 ton/ha compost were obtained. Biofertilizer also showed significant effects on mentioned traits except essential oil content. The highest biological yield, seed yield and essential oil yield were obtained by using the biofertilizer (inoculated seeds). Generally, the maximum seed yield and essential oil yield were obtained with the application of 10 ton/ha compost and biofertilizer.

Key Words: Dill, Compost, Azotobacter, Azospirillum, Essential oil.

Introduction

Dill (*Anethum graveolens* L.) is an annual herb which is native to mediterranean countries and southeastern Europe, used primarily as a condiment. Dill seed and leaves are used as flavouring in sauces, vinegars, pastries, and soups. Dill has medicinal value as a diuretic, stimulant, and a carminative. The dill seeds have essential oil as an active substance, while carvone and limonene are the main constituents of essential oil (Bailer et al., 2001; Singh et al., 2005; Callan et al., 2007). Using organic manures and biofertilizers such as compost and nitrogen fixing bacteria has led to a decrease in the application of chemical fertilizers and has provided high quality agricultural products (Migahed et al., 2004; Mahfouz and Sharaf Eldin, 2007). Composts are products containing living cells of different types of microorganisms that have an ability to convert nutritionally important elements from unavailable to available form through biological processes and are known to help with expansion of the root system and better seed germination (Vessey, 2003; Ebrahimi et al., 2010). Moreover, compost aids water absorption and retention by the soil, reducing erosion and run-off and help binding agricultural chemicals, and

Corresponding Author E-mail: darzi@riau.ac.ir

protecting ground water from contamination (Hussein et al., 2006). Free-living nitrogen fixing bacteria such as; *Azotobacter chroococcum* and *Azospirillum lipoferum,* were found to have not only the ability to fix nitrogen but also the ability to release phytohormones similar to gibberellic acid and indole acetic acid, which could stimulate plant growth, absorption of nutrients, and photosynthesis (El Ghadban et al., 2006; Mahfouz and Sharaf Eldin, 2007). By using correct nutritional sources through organic manures and biofertilizers, yield and active substances of medicinal plants can be maximized (Khalid et al., 2006; Leithy et al., 2009). Some studies have reported that compost can increase yield and secondry metabolites in a few medicinal plants such as thyme (Hendawy et al., 2010), dragonhead (Hussein et al., 2006), geranium (Leithy et al., 2009), basil (Khalid et al., 2006), psyllium (Hendawy, 2008), borage (Ebrahimi et al., 2010), fennel (Moradi et al., 2009; Moradi et al., 2011), chamomile (Fallahi et al., 2008; Arazmjo et al., 2010), cumin (Saeid Nejad and Rezvani Moghaddam, 2011), garlic (Suthar, 2009) and sesame (Rezvani Moghaddam et al., 2010). Several other studies have reported that biofertilizer such as nitrogen fixing bacteria could cause increased yield and active substances of some medicinal plants such as fennel (Abdou et al., 2004; Mahfouz and Sharaf Eldin, 2007; Azzaz et al., 2009; Moradi et al., 2011), lemon balm (Harshavardhan et al., 2007), turmeric (Velmurugan et al., 2008), hyssop (Koocheki et al., 2009), cumin (Saeid Nejad and Rezvani Moghaddam, 2010), black cumin (Valadabadi and Farahani, 2011) and dill (Darzi et al., 2012). Therefore, the main objective of the present field experiment was to investigate the influence of compost and biofertilizer on yield and essential oil of dill (*Anethum graveolens*).

Methods

Field Experiment

A factorial experiment, arranged in a randomized complete blocks designed with three replications, was conducted in the Experimental field of the Agriculture Company of Ran, Firouzkuh, Iran during the growing season of 2012. The geographical location of the experimental station was 35º 45´ N and 52º 44´ E with the altitude of 1930 m. The treatments consisted of different levels of compost (0, 5, 10 and 15 ton/ha) and biofertilizer, different inoculation conditions of mixture of *Azotobacter chroococcum* and *Azospirillum lipoferum* bacteria (non-inoculated and seed inoculated). Inoculation was carried out by dipping the dill seeds in the cells suspension of 10^8 CFU/ml for 15 min. The required quantities of compost were applied and incorporated to the top 5 cm layer of soil in the experimental beds before the plantation of dill seeds. Several Soil samples (0–30 cm depth) were taken for the nutrient and trace element analysis prior to land preparation. Chemical and physical properties of the experimental soil and compost are presented in Tables1 and 2. Each experimental plot was 3 m long and 2 m wide with the spacing of 10 cm between the plants and 40 cm between the rows. There was a space of one meter between the plots and 2 meters between replications. Dill seeds were directly sown by hand. There was no incidence of pest or disease on dill during the experiment. Weeding was done manually and the plots were irrigated weekly (as trickle irrigation system). All necessary cultural practices and plant protection measures were followed uniformly for all the plots during the entire period of experimentation. Twenty plants were randomly selected from each plot and the observations were recorded. Fifteen plants were randomly selected from each plot and the observations were recorded. In this study, quantitative and qualitative traits of dill consisted of biological yield, seed yield, essential oil content and essential oil yield were evaluated. For evaluating the biological yield, plants were put in the oven at 80º C for 48 h and dry weight was calculated using a digital balance (Sartorius B310S; ±0.01 g) (Migahed et al., 2004; Badran and Safwat, 2004). In order to determine seed yield, the plots were manually harvested following the air-drying of umbels and then the seeds were removed from plants by hand.

Extraction of Essential oil

In order to determine the essential oil content (%), a sample of 100 g of dill seeds from the each plot were crushed in electric grinder and were mixed with 500 ml distilled water and then were subjected to hydro-distillation for 3 h using a Clevenger-type apparatus (Kapoor et al., 2004; Darzi et al., 2012). Essential oil yield also was calculated with by using essential oil content and seed yield.

Table 1. Some Traits of Physical and Chemical of soil in experiment site

Cu (mg/kg)	Fe (mg/kg)	K (mg/kg)	P (mg/kg)	N (%)	O.C (%)	EC (ds/m)	pH	Texture
1.2	8	720	48	0.127	1.86	1.55	7.6	Clay-Loamy

Table 2. Some Characteristics of Chemical of used Compost

K	P	N	O.C	O.M	EC	pH
(%)					(ds/m)	
1.2	0.35	1.2	30	51	10.9	6.7

Statistical Analysis

All the data were subjected to statistical analysis (one-way ANOVA) using SAS software (SAS Institute, version 8, 2001). Differences between the treatments were performed by Duncan's Multiple Range Test (DMRT) at 5% confidence interval. Transformations were applied to the data to assure that the residuals had normal distribution (Zar, 1996).

Results and Discussion

Biological yield

The results have indicated that biological yield was affected by the application of compost (Figure 1). Significant increase in biological yield was observed in three treatments of compost application (5, 10 and 15 ton/ha) as compared to the control experiment (non-compopst). The highest biological yield were obtained with applying 15 ton/ha compost (7529.6 kg/ha). compost increases the growth rate because of the water and mineral uptake such as; nitrogen and phosphorus (Hendawy, 2008), which leads to the biological yield improvement. This finding is in accordance with the previous observations (Hendawy, 2008; Moradi et al., 2009; Leithy et al., 2009; Suthar, 2009; Saeid Nejad and Rezvani Moghaddam, 2011). Biofertilizer showed significant effect on biological yield (Table 3), as the highest biological yield (6802.5 kg/ha) was obtained in the second treatment level of nitrogen fixing bacteria (inoculated seeds). Effect of nitrogen fixing bacteria on the biological yield was due to increased nitrogen uptake (Mahfouz and Sharaf Eldin, 2007; Kalyanasundaram et al., 2008). The result of present work are in agreement with the reports of Swaminathan et al. (2008) and Kumar et al. (2009) on *Artemisia pallens*, Valadabadi and Farahani (2011) on *Nigella sativa* and Darzi and Haj Seyed Hadi (2012) on dill.

Seed yield

The results presented in Figure 2 have revealed that various levels of compost had significant effects on the seed yield. The maximum seed yield (1212.5 kg/ha) was obtained by using 10 ton compost per hectare. Increased seed yield in compost treatments can be owing to the improvement of yield components such as; umbel number per plant and biological yield. Our findings are in accordance with the observations of Fallahi et al. (2008) on chamomile, Moradi et al. (2009) on fennel, Rezvani Moghaddam et al. (2010) on sesame, Ebrahimi et al. (2010) on borage and Saeid Nejad and Rezvani Moghaddam (2011) on cumin. Significant increase in seed yield was observed in treatment of biofertilizer application (inoculated seeds) as compared to the control (Table 3). The highest seed yield (1082.9 kg/ha), however, was found after application of nitrogen fixing bacteria (mixture of *Azotobacter chroococcum* and *Azospirillum lipoferum*). Nitrogen fixing bacteria, promoted seed yield through the enhancement of yield attributes . These result are in agreement with the investigation of Kumar et al. (2002) on *Coriandrum sativum*, Migahed et al. (2004) on *Apium graveolens*, Abdou et al. (2004) and Mahfouz and Sharaf Eldin (2007) on *Foeniculum vulgare*, Valadabadi and Farahani (2011) on *Nigella sativa* and Darzi and Haj Seyed Hadi (2012) on *Anethum graveolens*.

Essential oil content

The results indicated that essential oil content was not affected by compost. This finding is in accordance with the observations of Fallahi et al. (2008) on *Matricaria recutita*, Saeid Nejad and Rezvani Moghaddam (2011) on *Cuminum cyminum* and Moradi et al. (2011) on *Foeniculum vulgare* (Figure 3). However, using 10 ton compost per hectare caused more essential oil content (3.27%). Also, The results indicated that essential oil content was not affected by biofertilizer, despite Inoculated seeds by nitrogen fixing bacteria showed more essential oil content (3.05%) in comparison to the control (2.85%)(Table 3).

Essential oil yield

The results presented in Figure 4 have demonstrated that essential oil yield was influenced by the application of compost, significantly. Among various levels, the application of 10 ton compost per hectare has indicated maximum increase in essential oil yield (39.7 kg/ha). Increased essential oil yield in compost treatments can be owing to the improvement of yield components such as; seed yield. Our findings are in accordance with the observations of Hussein et al. (2006) on dragonhead and Khalid et al. (2006) on basil, Fallahi et al. (2008), Hendawy et al. (2010) on thyme, Ahmadian et al. (2010) and Arazmjo et al. (2010) on chamomile, Saeid Nejad and Rezvani Moghaddam (2011) on cumin and Moradi et al. (2011) on fennel. Biofertilizer showed significant effect on essential oil yield (Table 3), as the highest essential oil yield (32.9 kg/ha) was obtained in the second treatment level of biofertilizer (inoculated seeds with azotobacter + azospirillum). Biofertilizer, promoted essential oil yield through the enhancement of yield attributes . These result are in agreement with the investigation of Abdou et al. (2004) and Mahfouz and Sharaf Eldin (2007) on *Foeniculum vulgare*, Swaminathan et al. (2008) and Kumar et al. (2009) on *Artemisia pallens*, Koocheki et al. (2009) on *Hyssopus officinalis*, Saeid Nejad and Rezvani Moghaddam (2010) on *Cuminum cyminum*, Valadabadi and Farahani (2011) on *Nigella sativa* and Darzi et al. (2012) on *Anethum graveolens*.

Table 3. Mean comparison of the quantitative and qualitative characteristics of dill at various levels of biofertilizer

Treatments	Biological yield (kg/ha)	Seed yield (kg/ha)	Essential oil content (%)	Essential oil yield (kg/ha)
Biofertilizer				
b1	5570.2 b	887.6 b	2.85 a	26.0 b
b2	6802.5 a	1082.9 a	3.05 a	32.9 a

Means, in each column for each factor followed by at least on letter in common, are not significantly different at 5% probability level using Duncans' Multiple Range Test.

b1 and b2 represent non-inoculated and inoculated seeds by azotobacter + azospirillum, respectively.

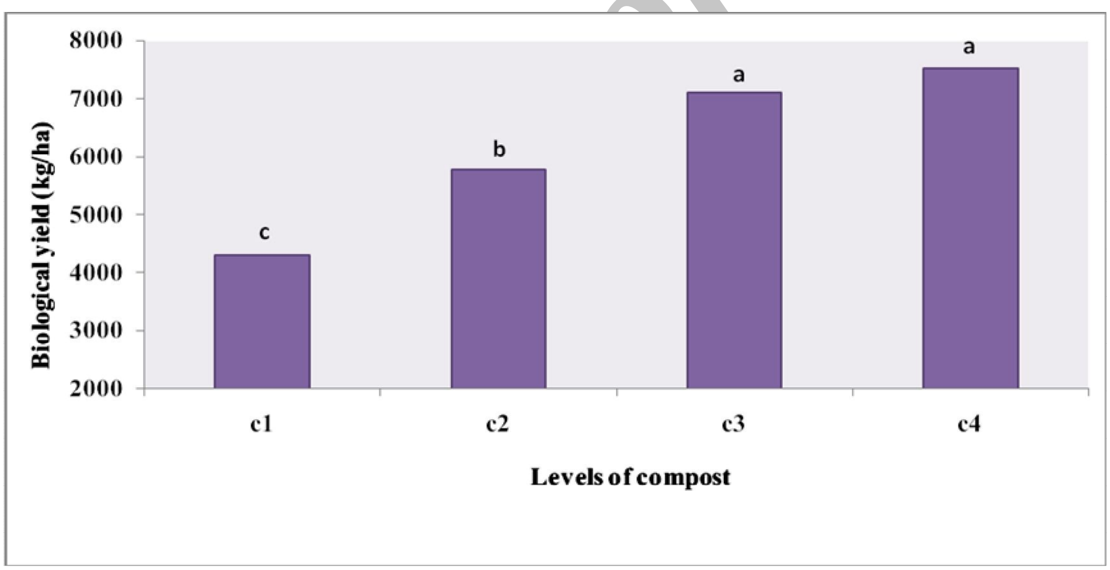

Figure 1. Mean comparison for biological yield in different levels of compost

c1, c2, c3 and c4 represent 0, 5, 10 and 15 ton compost per hectare, respectively.

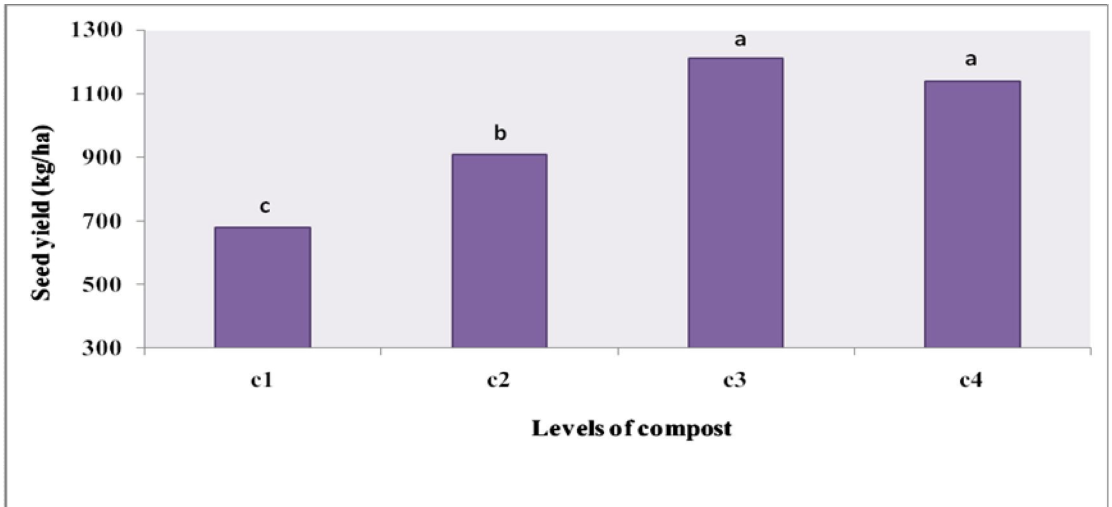

Figure 2. Mean comparison for seed yield in different levels of compost

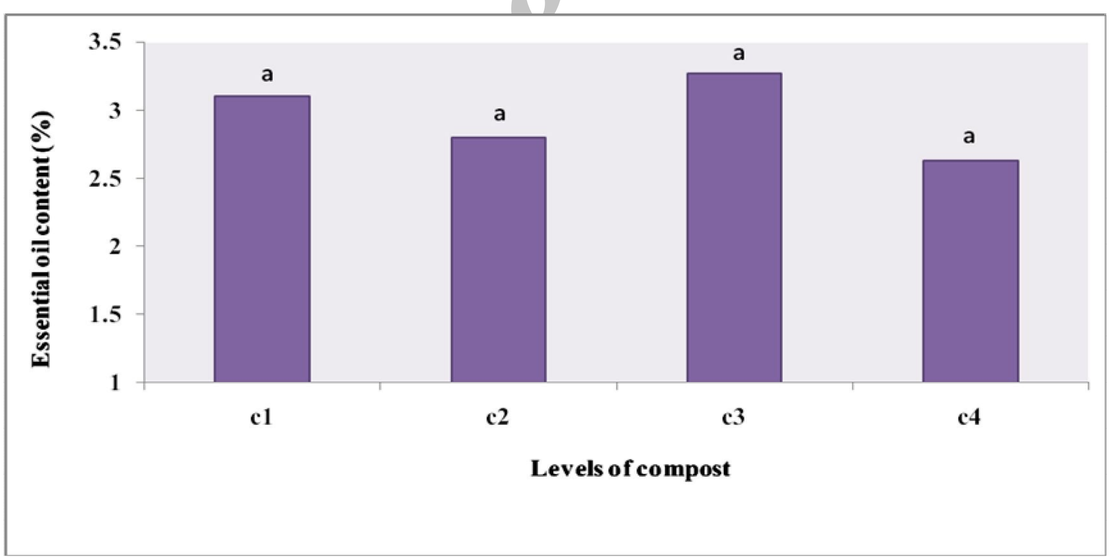

Figure 3. Mean comparison for essential oil content in different levels of compost

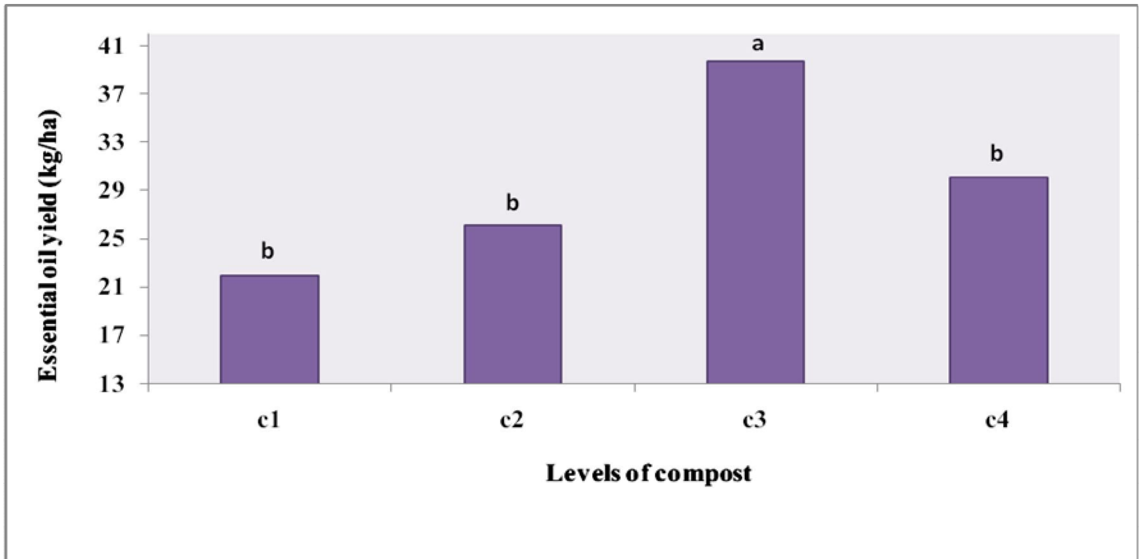

Figure 4. Mean comparison for essential oil yield in different levels of compost

Conclusion

Generally, it could be concluded that under Firouzkuh environmental conditions, the application of 10 ton/ha compost and biofertilizer (azotobacter and azospirillum bacteria) is recommended for improvement of yields (seed and essential oil) in dill.

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