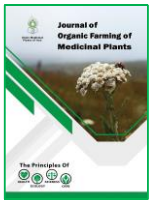
Journal of Organic Farming of Medicinal Plants: September 2023; 2 (3): 103-107
Available online at http://www.jofmp.areeo.ac.ir



Original Article

Integrated Effects of Bio-Fertilizers on Essential Oil Quality of Basil (*Ocimum basilicum* L.)

Nazanin Roshanpour

Department of Agronomy and Plant Breeding, Roudehen Branch, Islamic Azad University, Roudehen, Iran.

ARTICLE INFO

Corressponding Author:
Farnaz Shahmohammadi
Zohreh_triticum@yahoo.com

Received: 28 September 2025
Accepted: 4 November 2025

Keywords:
Dill
Compost
Azotobacter
Azospirillum
Essential oil

ABSTRACT

A field experiment was conducted in 2021 at Firouzkuh, Iran, to investigate the effects of organic and bio-fertilizers on seed yield and essential-oil production in dill (*Anethum graveolens* L.). The study was arranged as a randomized complete block design with three replicates. Treatments included four fertilizer regimes: vermicompost at 6 t ha^{-1}, inoculation with a mixture of *Azotobacter chroococcum* and *Azospirillum lipoferum*, a combined treatment (vermicompost + inoculation), and an unfertilized control. Results showed that both organic and bio-fertilizers significantly improved seed yield and essential-oil traits compared with the control. The combined treatment produced the highest seed yield (1,246 kg ha^{-1}), essential-oil content (2.11%), and essential-oil yield (26.3 kg ha^{-1}). Vermicompost alone also had strong positive effects, whereas bacterial inoculation mainly enhanced oil yield by increasing seed production. The findings suggest that integrating organic amendments with nitrogen-fixing bacteria can be an effective strategy to enhance both the quantity and quality of dill essential oil in sustainable cropping systems.

1. Introduction

Dill (*Anethum graveolens* L.) is an annual aromatic plant belonging to the Apiaceae family. It is widely cultivated in many parts of the world for its seeds and leaves, which are valued as spices, flavoring agents, and medicinal ingredients. Dill essential oil contains a variety of bioactive compounds, including carvone and limonene, which contribute to its distinctive aroma and its pharmaceutical properties such as carminative, antimicrobial, and antioxidant effects (Moghaddam et al., 2013; Singh et al., 2016).

In recent years, demand for medicinal and aromatic plants has increased due to their use in the pharmaceutical, cosmetic, and food industries. Consequently, improving both the yield and quality of essential oils from such plants has become a priority in sustainable agriculture. Conventional production relies heavily on chemical fertilizers, which can lead to environmental degradation, soil fertility decline, and reduced essential-oil quality. Therefore, alternative fertilization strategies using organic and bio-fertilizers have received considerable attention (Mahfouz & Sharaf Eldin, 2007; Anwar et al., 2005).

Vermicompost, a nutrient-rich organic amendment derived from the activity of earthworms, improves soil structure, enhances microbial activity, and supplies essential nutrients. Numerous studies have demonstrated its positive effects on the yield and essential-oil composition of medicinal plants such as basil, fennel, chamomile, and coriander (Singh & Ramesh, 2002; Anwar et al., 2005; Darzi et al., 2009; Haj Seyed Hadi et al., 2011). Likewise, bio-fertilizers containing nitrogen-fixing bacteria such as *Azotobacter chroococcum* and *Azospirillum lipoferum* enhance nutrient uptake and stimulate plant growth and secondary metabolism. Positive effects have been reported in crops such as fennel, cumin, and dill (Abdou et al., 2004; Moradi et al., 2011; Darzi et al., 2012).

However, there is limited information on the combined effects of vermicompost and nitrogen-fixing bacteria on dill performance and essential-oil production. Given the importance of dill as a medicinal and aromatic crop, the present study was conducted to evaluate the individual and interactive effects of organic and bio-fertilizers on seed yield, essential-oil content, and essential-oil yield of dill under field conditions in Iran.

2. Materials and Methods

2.1. Experimental Site and Design

The field experiment was carried out during the 2021 growing season at the Experimental Farm of the Agriculture Company of Ran, Firouzkuh, Iran (35°45′ N, 52°44′ E; altitude 1930 m). The experimental field soil had a clay-loamy texture, a pH of 7.6, an electrical conductivity of 1.55 dS m^{-1}, organic carbon of 1.86%, total nitrogen of 0.127%, available phosphorus of 48 mg kg^{-1}, and available potassium of 720 mg kg^{-1}. A 4-treatment randomized complete block design (RCBD) with three replications was used. Treatments were: (1) unfertilized control, (2) vermicompost at 6 t ha^{-1}, (3) inoculation with a mixture of *Azotobacter chroococcum* and *Azospirillum lipoferum*, and (4) vermicompost + inoculation.

2.2. Compost and Inoculum Preparation

Compost was produced from livestock manure. Chemical properties of the icompost are presented in Table 1. Bacterial inoculation was performed by immersing dill seeds in a suspension of *A. chroococcum* and *A. lipoferum* (10^8 CFU ml^{-1}) for 15 minutes immediately before sowing.

Table 1. Selected chemical properties of the compost used

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

2.3. Crop Management

Plots measured 3 × 2 m, each consisting of rows 40 cm apart with 10 cm between plants within rows. One-meter alleys separated plots, and two meters separated replications. Seeds were hand-sown directly in the field. Weeds were removed manually, and drip irrigation was applied weekly to maintain soil moisture. No major pest or disease infestations occurred during the experiment.

2.4. Data Collection

At maturity, 20 plants per plot were randomly sampled for measurement. Traits recorded included seed yield (kg ha^{-1}), essential-oil content (%), and essential-oil yield (kg ha^{-1}).

2.5. Essential Oil Extraction

For essential-oil extraction, 100 g of air-dried seeds from each treatment were ground and subjected to hydro-distillation using a Clevenger apparatus for 3 h. Essential-oil content (%) was calculated as the ratio of extracted oil weight to dry seed weight. Essential-oil yield (kg ha^{-1}) was derived by multiplying oil content by seed yield.

2.6 Statistical Analysis

Data were subjected to analysis of variance (ANOVA) using SAS software (version 9.1). Treatment means were compared using Duncan's Multiple Range Test (DMRT) at the 5% probability level.

3. Results

3.1. 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). Biofertilizer showed significant effect on biological yield (Table 2), as the highest biological yield (6802.5 kg/ha) was obtained in the second treatment level of nitrogen fixing bacteria (inoculated seeds).

3.2. Seed yield

Fertilizer treatments significantly affected seed yield (Figure 1; Table 2). The highest yield (1,246 kg ha^{-1}) was obtained from the combined application of vermicompost and bacterial inoculation, followed by vermicompost alone (1,108 kg ha^{-1}). Inoculation alone also improved yield compared with the control (935 vs. 742 kg ha^{-1}).

3.3. Essential oil content

Essential-oil content was significantly influenced by fertilizer regime (Figure 2). The maximum value (2.11%) was recorded for the combined treatment, while the lowest (1.52%) was observed in the control. Vermicompost alone (1.97%) and inoculation alone (1.71%) showed intermediate values.

3.4. Essential oil yield

Essential-oil yield, derived from the product of seed yield and oil content, was highest under the combined treatment (26.3 kg ha^{-1}), which was significantly greater than vermicompost alone (21.9 kg ha^{-1}), inoculation alone (16.0 kg ha^{-1}), and the control (11.3 kg ha^{-1}) (Figure 3; Table 2).

4. Discussion

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.

Table 2. Mean comparison of th`e quantitative and qualitative characteristics of dill at various levels of biofertilizer

Treatments	Biological yield (kg ha^{-1})	Seed yield (kg ha^{-1})	Essential oil content (%)	Essential oil yield (kg ha^{-1})
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 within a column followed by different letters are significantly different at the 5% probability level (DMRT). b1 and b2 represent non-inoculated and inoculated seeds by azotobacter + azospirillum, respectively.

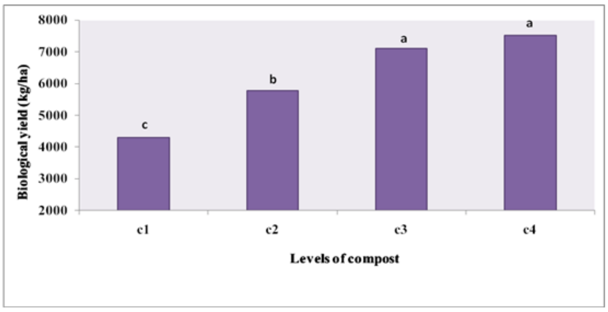


Fig 1. Biological yield of dill under different fertilizer treatments. c1, c2, c3 and c4 represent 0, 5, 10 and 15 ton compost per hectare, respectively.

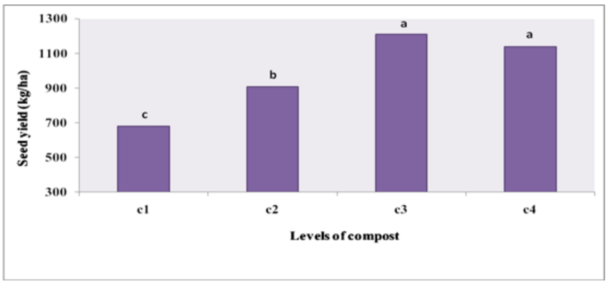


Fig 2. Seed yield of dill under different fertilizer treatments.

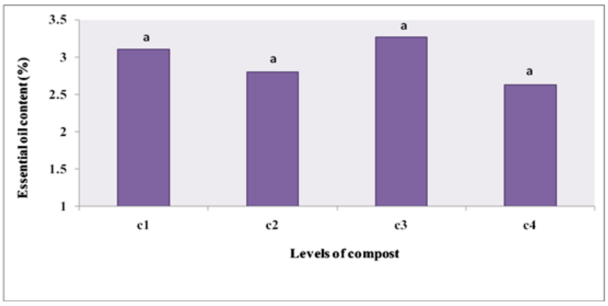


Fig 3. Essential-oil content of dill under different fertilizer treatments.

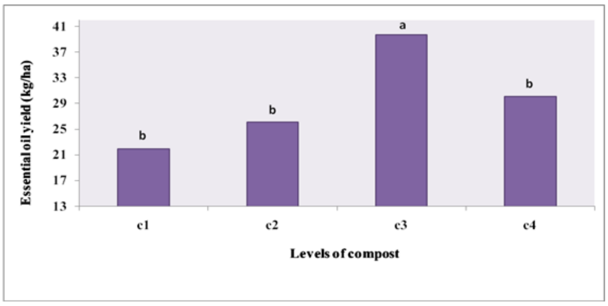


Fig 4. Essential-oil yield of dill under different fertilizer treatments.

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). 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.

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. 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*.

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, 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*.

5. Conclusion

This study confirmed that both compost and nitrogen-fixing bacteria significantly enhance seed yield and essential-oil production in dill. Compost application improved soil fertility and increased both seed and essential-oil traits, while bacterial inoculation enhanced nitrogen availability and promoted plant growth. The combined treatment of compost with inoculation produced the highest values for seed yield (1,246 kg ha⁻¹), essential-oil content (2.11%), and essential-oil yield (26.3 kg ha⁻¹), demonstrating a clear synergistic effect.

These results highlight the potential of integrating organic amendments with bio-fertilizers as a sustainable alternative to chemical fertilizers. Such practices not only improve crop productivity but also contribute to environmental protection and long-term soil health. Future research should focus on multi-year field evaluations and the optimization of integrated nutrient management strategies to maximize both yield and essential-oil quality in dill and other medicinal plants.

References

Abdou, M.A.H., El Sayed. A.A., Badran, F.S. & El Deen, R.M.S. (2004). Effect of planting density and chemical and biofertilization on vegetative growth, yield and chemical composition of fennel (*Foeniculum vulgare* Miller): I - Effect of planting density and some chemical (Nofatrein) and biochemical (Biogen) fertilizers. *Annals of Agricultural Science*. 42(4), 1907-1922.

Ahmadian, A., Ghanbari, A., Siahsar, B.A., Heidary, M., Ramroodi, M. & Mousavinik, M. (2010). Effects of Residual of chemical fertilizer, cattle manure and compost on yield, yield components, some physiological characterestics and essential oil content of Matricaria chamomilla under drought stress condition. *Iranian Journal of Field Crops Research*. 8(4), 668-676.

Arazmjo, A., Heidari, M., Ghanbari, A., Siahsar, B. & Ahmadian, A. (2010). Effects of three types of fertilizers on essential oil, photosynthetic pigments, and osmoregulators in chamomile under drought stress. *Environmental Stresses in Crop Sciences*. 3(1), 23-33.

Azzaz, N.A., Hassan, E.A. & Hamad, E.H. (2009). The chemical constituent and vegetative and yielding characteristics of fennel plants treated with organic and bio-fertilizer instead of mineral fertilizer. *Australian Journal of Basic and Applied Science*. 3(2), 579-587.

Badran, F.S. & Safwat, M.S. (2004). Response of fennel plants to organic manure and bio-fertilizers in replacement of chemical fertilization .*Egyptian Journal of Agricultural Research*. 82(2), 247-256.

Bailer, J., Aichinger, T., Hackl, G., Hueber, K. & Dachler, M. (2001). Essential oil content and composition in commercially available dill cultivars in comparison to caraway. *Industrial Crops and Products*. 14, 229-239.

Callan, N.W., Johnson, D.L., Westcott, M.P. & Welty, L.E. (2007). Herb and oil composition of dill (*Anethum graveolens* L.): Effects of crop maturity and plant density. *Industrial Crops and Products*. 25, 282–287.

Darzi, M.T. & Haj Seyed Hadi, M.R. (2012). Effects of the application of organic manure and biofertilizer on the fruit yield and yield components in Dill (*Anethum graveolens*). *Journal of Medicinal Plants Research*. 6(16), 3266-3271.

Darzi, M.T., Haj Seyed Hadi, M.R. & Rejali, F. (2012). Effects of the application of vermicompost and nitrogen fixing bacteria on quantity and quality of the essential oil in dill (*Anethum graveolens*). *Journal of Medicinal Plants Research*. 6(21), 3793-3799.

Ebrahimi, A., Moaveni, P. & Aliabadi Farahani, H. (2010). Effects of planting dates and compost on mucilage variations in borage (*Borago officinalis* L.) under different chemical fertilization systems. *International Journal for Biotechnology and Molecular Biology Research*. 1(5), 58-61.

El Ghadban, E.A.E., Shalan, M.N.& Abdel Latif, T.A.T. (2006). Influence of biofertilizers on growth, volatile oil yieldand constituents of fennel (*Foeniculum vulgare* Mill.). *Egyptian Journal of Agricultural Research*. 84(3), 977-992.

Fallahi, J., Koocheki, A.& Rezvani Moghaddam, P. (2008). Investigating the effects of organic fertilizer on quantity index and the amount essential oil and chamazulene in chamomile (*Matricaria recutita*). *Agricultural Research: Water, Soil and Plant in Agriculture*. 1(8), 157-168.

Harshavardhan, P.G., Vasundhara, M., Shetty, G.R., Nataraja, A., Sreeramu, B.S., Gowda, M.C.& Sreenivasappa, K.N. (2007). Influence of spacing and integrated nutrient management on yield and quality of essential oil in lemon balm (Mellisa officinalis L). *Biomedicines*. 2(3), 288-292.

Hendawy, S.F. (2008). Comparative Study of Organic and Mineral Fertilization on *Plantago arenaria* Plant. *Journal of Applied Sciences Research*. 4(5), 500-506.

Hendawy, S.F., Azza, A., El-Din, E., Aziz, E. & Omer, E.A. (2010). Productivity and oil quality of *Thymus vulgaris* L. under organic fertilization conditions. Ozean Journal of Applied Sciences. 3(2), 203-216.

Hussein, M.S., El-Sherbeny, S.E., Khalil, M.Y., Naguib, N.Y. & Aly, S.M. (2006). Growth characters and chemical constituents of *Dracocephalum moldavica* L. plants in relation to compost fertilizer and planting distance. *Scientia Horticulturae*. 108, 322-331.

Kalyanasundaram, B., Kumar, T.S., Kumar, S. & Swaminathan, V. (2008). Effect of N, P, with biofertilizers and vermicompost on growth and physiological characteristics of sweet flag (Acorus calamus L.). *Advances in Plant Science*. 21(1), 323-326.

Kapoor, R., Giri, B. & Mukerji, K.G. (2004). Improved growth and essential oil yield and quality in *Foeniculum vulgare Mill* on mycorrhizal inoculation supplemented with P-fertilizer. *Bioresource Technology*. 93, 307-311.

Khalid, K.H.A., Hendawy, S.F. & El-Gezawy, E. (2006). *Ocimum basilicum* L. Production under Organic Farming. *Research Journal of Agriculture and Biological Sciecnes*. 2(1), 25-32.

Koocheki, A., Tabrizi, L.& Ghorbani, R. (2009). Effect of biofertilizers on agronomic and quality criteria of Hyssop *(Hyssopus officinalis). Iranian Journal of Agronomy Research*. 6(1), 127-137.

Kumar, S., Choudhary, G.R. & Chaudhari, A.C. (2002). Effects of nitrogen and biofertilizers on the yield and quality of coriander (*Coriandrum sativum* L.). *Annals Agricultural Research*. 23(4),634-637.

Kumar, T.S., Swaminathan, V. & Kumar, S. (2009). Influence of nitrogen, phosphorus and biofertilizers on growth, yield and essential oil constituents in ratoon crop of davana (*Artemisia pallens* Wall.). *Electronic Journal of Environment, Agriculture and Food Chemistry*. 8(2), 86-95.

Leithy, S., Gaballah, M.S. & Gomaa, A.M. (2009). Associative impact of bio- and organic fertilizers on geranium plants grown under saline conditions. *International Journal of Academic Research*. 1(1), 17-23.

Mahfouz, S.A.& Sharaf Eldin, M.A. (2007). Effect of mineral vs. biofertilizer on growth, yield, and essential oil content of fennel (*Foeniculum vulgare* Mill). *International Agrophisics*. 21(4), 361-366.

Migahed, H.A., Ahmed, A.E. & Abdel Ghany, B.F. (2004). Effect of different bacterial strains as biofertilizer agents on growth, production and oil of Apium graveolens under calcareous soil. *Arab Universities Journal of Agricultural Science*. 12(2), 511-525.

Moradi, R., Nasiri Mahallati, M., Rezvani Moghaddam, P., Lakzian, A. & Nejad Ali, A. (2011). The effect of application of organic and biological fertilizers on quantity and quality of essential oil in fennel (*Foeniculum vulgare*). *Journal of Horticutural Science*. 25(1), 25-33.

Moradi, R., Rezvani Moghaddam, P., Nasiri Mahallati, M. & Lakzian, A. (2009). The effect of application of organic and biological fertilizers on yield, yield components and essential oil of *Foeniculum vulgare* (Fennel). *Iranian Journal of Field Crops Research*. 7(2), 625-635.

Rezvani Moghaddam, P., Mohammad Abadi, A.A. & Moradi, R. (2010). Effects of chemical fertilizer and organic manure on yield and yield components of sesame (*Sesamum indicum* L.) in different densities. *Journal of Agroecology*. 2(2), 256-265.

Saeid Nejad, A.H. & Rezvani Moghaddam, P. (2010). Evaluation of biofertilizer and chemical fertilizer application on morphological traits, yield, yield components and essential oil percent in cumin (*Cuminum cyminum*). *Journal of Horticultural Science*. 24(1), 38-44.

Saeid Nejad, A.H. & Rezvani Moghaddam, P. (2011). Evaluation of compost, vermicompost and cattle manure application on yield, yield components and essential oil percent in cumin (*Cuminum cyminum*). *Journal of Horticultural Science*. 24(2), 142-148.

Singh, G., Maurya, S., De Lampasona, M.P. & Catalan, C. (2005). Chemical Constituents, Antimicrobial Investigations, and Antioxidative Potentials of *Anethum graveolens* L. Essential Oil and Acetone Extract: Part 52. *Journal of Food Science*. 70(4), M208-M215.

Suthar, S. (2009). Impact of vermicompost and composted farmyard manure on growth and yield of garlic (*Allium stivum* L.) field crop. *International Journal of Plant Production*. 3(1), 27-38.

Swaminathan, V., Kumar, T.S., Sadasakthi, A., Balasubramanian, R. (2008). Effect of nitrogen and phosphorus along with biofertilizers on growth, yield and physiological characteristics of Davana (*Artemisia pallens* Wall.). *Advances in Plant Science*. 21(2), 693-695.

Valadabadi, S.A. & Farahani, H.A. (2011). Investigation of biofertilizers influence on quantity and quality characteristics in *Nigella sativa* L. *Journal of Horticulture and Forestry*. 3(3), 88-92.

Velmurugan, M., Chezhiyan, N. & Jawaharlal, M. (2008). Influence of organic manures and inorganic fertilizers on cured rhizome yield and quality of turmeric (*Curcuma longa* L.) cv. BSR-2. *International Journal of Agricultural Science*. 4(1), 142-145.

- Vessey, J.K. (2003). Plant growth promoting rhizobacteria as biofertilizers. *Plant and Soil*. 255, 571–586.