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Effect of Planting Date and Vermicompost on Seed and Essence Production of Dill (*Anethum graveolens* L.)

Hossein Zahedi* and Siavash Jahanshahi**
**Department of Agronomy and Plant Breeding, Islamshahr Branch, Islamic Azad University, Islamshahr, IRAN*
***Department of Agronomy, Shahr-e-Rey Branch, Islamic Azad University, Shahr-e-Rey, IRAN*

(Corresponding author: Hossein Zahedi)
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ABSTRACT: Vermicomposts are organic compounds which are able to change basic nutrients into an available form through biological procedures, and are an important source of nutrients in sustainable agriculture. In order to investigate the effect of different vermicompost rates and planting dates on dill (*Anethum graveolens* L.), an experiment was conducted at Shahre-Rey, Iran, during the 2012 growing season. The experimental design was randomized in complete blocks arranged in split plots with four replications. The factors included four planting dates:13th and 23April and April 3rdand 13thMay for main plots, and for sub-plots five levels of vermicompost, 0, 8, 16, 24 and 32 tons per hectare, were used. Findings suggested that application of 32 tons per hectare vermicompost significantly increased biological yield, essence yield, harvest index, seeds yield and seed essence yield. In addition, in most cases, the 13th and 23rd April planting dates were found to be the most effective dates for the abovementioned traits. Therefore, application of 32 ton per hectare vermicompost and seed sowing in April is recommended to gain the highest seed and essence yield.

Keywords: Planting date, Vermicompost, Essence yield, Dill, Seed yield

INTRODUCTION

Dill (*Anethum graveolens* L.), also known as Lao coriander depending on where it is grown, is either a perennial or annual aromatic herbaceous plant belonging to the Umbelliferae or Apiaceae family. Dill has three species *graveolens*, *krizium* and *inolocratum*, and is native to India spreading later to the Mediterranean and Europe, and then to America and Japan (Bailer *et al.,* 2001). The plant has potential importance as a medicinal herb that contains volatile oils such as B-camphene-pinene, anethole, lonone, umbelliferone and carvone (Dhalwal *et al.,* 2008; Sharma, 2004). Dill is used as an antibacterial plant in some conditions such as stomachache. Other essences found in this plant include limonen, dihydrocaron, alfapinen, terpinen, terpenoeid (Havlin *et al.,* 2005). The dill seeds have essential oil as an active substance, while carvone and limonene are the most important constituents of dill, which is used in the pharmaceutical industry as a diuretic, a stimulant and a carminative (Bailer *et al.,* 2001; Singh et al., 2005; Callan *et al.,* 2007).

Application of organic fertilizer such as cattle manure and vermicompost has led to a decrease in the use of chemical fertilizers, and has provided high-quality products free of harmful agrochemicals for human safety (Sharma, 2002; Mahfouz and Sharaf Eldin, 2007). Vermicomposts are the products of the degradation of organic matter through interactions between earthworms and microorganisms. They are finely divided peat-like materials with high porosity, aeration, drainage and water-holding capacity, and usually contain most nutrients in available forms such as nitrates, phosphates, exchange able calcium and soluble potassium (Atiyeh *et al.,* 2002; Arancon *et al.,* 2005). Vermicompost has large particulate surface area that provides many microsites for microbial activity and strong retention of nutrients. It is rich in microbial population and diversity, particularly in fungi, bacteria and actinomycetes. It contains plant growth regulators and other growth-influencing materials produced by microorganisms (Atiyeh *et al.,* 2002; Arancon *et al.,* 2005).It has been reported that by using correct nutritional sources through organic manures and biofertilizers, the quantity and quality of active substances, such as essential oil in medicinal plants, can be maximized (Darzi *et al.,* 2012).Several studies have reported that vermicompost can increase the growth and biomass of some medicinal plants such as basil (Singh and Ramesh, 2002; Anwar *et al.*,2005), plantain (Sanchez *et al.,* 2008), coriander(Singh *et al.,* 2009), fennel (Darzi *et al.,* 2007), cumin (Saeid Nejad and Rezvani Moghaddam, 2011) and anise (Darzi *et al.,* 2012).

The effects of the sowing date and its interaction with the environment on dill seed quality are not well understood, although it is known that high temperatures during seed development can give lower seed quality in other crops (Greven *et al.*, 2004). On the other hand, low temperatures may affect yields in two ways: first, because emergence from the seed bed may be worse than expected, so that plant population density may be sub-optimal; and second, because the growth rate of those plants that do emerge may be lower than those grown under optimum temperatures.

The aim of the present study was to investigate the effect of planting date and vermicompost application on essence percentage and yield, biological yield and seed production of dill plant.

MATERIALS AND METHODS

This experiment was carried out during the growing season of 2012 at Shahre-Rey, Iran. The geographic coordinates of the experimental station are 35° 25´ N and 51° 34´ E, with the altitude of 1060 m. The research site was ploughed in March 2012, and then harrowed to prepare the seed bed. Soil samples were taken from different parts of the land at depths of 0-30 and 30-60 cm to evaluate chemical and physical properties of the soil. The soil analysis results are presented in Table 1. The vermicompost treatments (0, 8, 16, 24 and 32 ton per hectare) were applied and incorporated into the top 5 cm layer of soil in the experimental beds before seed sowing. Seeds of dill were planted on 13th and 23rd April and 3rdand 13th May in 3m long rows with 75cm between them. The total area of the experimental unit was 9m. Dill seeds were directly sown by hand at a rate of five to six seeds per cavity and at a distance of 25cm in between. Irrigation was performed immediately. At seedling emergence stage, weeds were controlled using a hoe. After two weeks, seedlings were thinned to only two. All agricultural practices were done at the same until harvest time. There was no incidence of pest or disease on dill during the experiment. At flowering and maturity stages, harvests were carried out by cutting plant tops 1.5–2 cm above the soil. Essence percentage, essence yield and biological yield were inspected at flowering stage, and seed yield, biological yield, harvest index, essence percentage and essence yield were inspected directly after harvesting.

In order to determine the essential oil content (%), a sample of 100 g of dill seeds or leaves from each treatment were crushed in an electric grinder and mixed with 500 ml distilled water. Then, they were subjected to hydro-distillation for 3 h, using a Clevenger-type apparatus. The essential oil content was measured after dehydrating water by anhydrous sodium sulphate (Sephidkon, 2002; Kapoor *et al.*, 2004). Essential oil yield also was calculated using the essential oil content (Darzi *et al.*, 2012). The experiment was designed as a split plot experiment with two factors in a randomized complete block design with four replicates. All the data were subjected to statistical analysis (one-way ANOVA) using SAS software. Differences between the treatments were performed by Duncan's multiple range test (DMRT) at5% confidence interval.

Table 1: Chemical and physical properties of the soil.

Depth	EC ds/m	pH	TNV %	OC %	Total N %	P p.p.m	K p.p.m	Clay %	Silt %	Sand %	Texture	Fe p.p.m	Zn p.p.m	Cu p.p.m	Mn p.p.m	B p.p.m
0-30 cm	7.69	7.81	29.72	0.8	0.08	20	350	31	41	28	Clay loam	2.92	0.57	0.87	9.47	2.4
30-60 cm	5.07	8.02	27.28	0.7	0.08	16	361	37	35	28	Clay loam	3.77	0.52	0.77	7.44	2.4

RESULTS AND DISCUSSION

Analysis of variance indicated that the effects of planting date and vermicompost were significant on all studied traits of dill plants. In addition, interaction between planting date and vermicompost was statistically significant (Table 2). Comparisons of means are given in Table 3. According to the results, the greatest percentage of essence at the flowering stage was obtained when dill seeds were sown on 3rdand 13thMay and treated with 0, 8 and 16 ton per hectare vermicompost (Table 3). On the other hand, the lowest essence percentage was observed when seeds were sown on 13th and 23rd April and 3rd May, and treated with 16, 24 and 32 ton per hectare vermicompost (Table 3). These findings are in accordance with the observations of Pandey (2005).

Table 2: Analysis of variance on some dill traits.

Source of variations	df	Essence percentage at flowering	Biological yield at flowering	Essence yield at flowering	Seed yield	Biological yield	Harvest index	Seed essence percentage	Seed essence yield
Block	3	ns	ns	*	**	*	ns	*	ns
Planting date	3	*	**	*	*	**	**	**	**
Error a	9	7.65	13084.97	70.38	36675.33	116355.69	21.78	0.33	65.90
Vermicompost	4	**	**	**	**	**	**	**	**
Planting date × Vermicompost	12	**	*	**	**	**	**	**	**
Error b	48	5.78	4651.04	170.61	120004.73	99965.20	58.26	0.31	101.71
C.V (%)		16.03	7.82	20.21	13.39	10.93	5.25	19.80	17.49

*, ** and ns significant at 0.05, 0.01 and no significant respectively

Table 3: Interaction between planting date and vermicompost on some traits of dill.

Treatments	Essence percentage at flowering	Biological yield at flowering (kg ha^{-1})	Essence yield at flowering (kg ha^{-1})	Seed yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index (%)	Seed essence percentage	Seed essence yield (kg ha^{-1})
P1V1	1.08bcd	2411cde	26.03cd	1258g	4558fghi	26.48de	2.36bcde	29.88c
P1V2	1.04cde	2522cde	26.22cd	1375fg	4985defg	26.39de	2.22def	30.25c
P1V3	1.00def	2847bc	28.47bcd	1485defg	5335bcd	26.72de	2.21def	32.96c
P1V4	0.85f	3530ab	30.00ab	2033bc	5728b	34.22abc	2.10f	42.39b
P1V5	0.82f	3702a	30.35a	2463a	6465a	37.07a	2.08f	50.25a
P2V1	1.11bcd	2294de	25.46d	1238g	4435ghi	26.80de	2.37bcde	29.08c
P2V2	1.10bcd	2375cde	26.12cd	1358fg	4903defgh	26.57de	2.24cdef	30.29c
P2V3	1.05cde	2705bcd	28.40bcd	1420efg	5125cde	26.61de	2.23cdef	31.60c
P2V4	0.87f	3440ab	29.92ab	1960bc	5710b	33.30abcd	2.12f	41.56b
P2V5	0.85f	3555ab	30.21ab	2295ab	6305a	35.17ab	2.11f	48.48a
P3V1	1.16abc	2189de	25.42d	1201g	4260hi	27.11def	2.68ab	32.10c
P3V2	1.14abc	2248de	25.62d	1290g	4718efghi	26.12de	2.44bc	31.67c
P3V3	1.13abc	2500cde	28.25bcd	1353fg	4778efghi	27.62def	2.39bcd	32.23c
P3V4	1.03cde	2900bc	29.87ab	1875bcd	5685b	31.91cdef	2.17ef	40.56b
P3V5	0.95ef	3099b	29.44abc	1928bcd	5698b	32.57bcde	2.13f	41.04b
P4V1	1.24a	2050e	25.39d	1088g	4068i	24.81e	2.86a	31.01c
P4V2	1.18ab	2163de	25.52d	1265g	4598fghi	26.27de	2.63abc	33.69c
P4V3	1.15abc	2420cde	27.83bcd	1348fg	4753efghi	27.76def	2.48bc	33.72c
P4V4	1.09bcd	2683bcd	29.24abc	1795cdef	5078cdef	34.14abc	2.19ef	39.02b
P4V5	1.03cde	2863bc	29.48abc	1830cde	5503bc	32.35bcde	2.16ef	39.80b

P1: seed sowing on 13th of April, P2: seed sowing on 23rd of April, P3: seed sowing on 3rd of May, P4: seed sowing on 13th of May, V1: 0 ton per hectare vermicompost, V2: 8 ton per hectare vermicompost, V3: 16 ton per hectare vermicompost, V4: 24 ton per hectare vermicompost, V5: 32 ton per hectare vermicompost. Values within the each column and followed by the same letter are not different at $P < 0.05$ by an ANOVA protected Duncan's Multiple Range Test.

Borna *et al.* (2007) reported that planting date had no significant effect on essence percentage of *Dracocephalummoldavica* L., which contrasts with the result of this study. Zarinzadeh *et al.* (2007) reported the significant effect of planting date on cumin aldehyde content. Biological yield at flowering stage significantly increased when seed sowing was performed on 13th and 23rdApril and plots were treated with 24 or 32 ton per hectare vermicompost (Table 3). The lowest biological yield was produced when plots were treated with the lowest amount of vermicompost, especially when seeds were sown late (Table 3). Vermicompost application through the improvement of biological activities of soil and mineral element absorption (Jat and Ahlawat, 2004; Zaller, 2007), caused more biomass production. Furthermore, early planting dates help plants to use growth factors more efficiently, such as water and nitrogen.

Application of 24 and 32 ton per hectare vermicompost had a great impact on the essence yield of the leaves at flowering stage. Irrespective of planting dates, the highest essence yield was related to these fertilizer treatments. There were no significant differences between other treatments in respect of essence yield (Table 3).The highest seed yield was gained when 24 or 32 ton per hectare vermicompost was applied on each planting date. Seed yield registered the minimum amount when 0, 8 or 16 ton per hectare vermicompost was used (Table 3).Increased seed yield in vermicompost treatments can be owing to the improvement of umbel number per plant and dry weight of plant. Our findings are in accordance with the observations of Sanchez *et al.* (2008) and Moradi *et al.* (2010). Rahmani *et al.* (2008) reported that nitrogen effect was significant on the oil yield, seed yield, oil percent, grain weight, number of seeds and grain diameter based on *Calendula officinalis* L. The highest biological yield was obtained when seeds were sown on 13th and 23rdApril and treated with 32 ton per hectare vermicompost (Table 3). On the other hand, the lowest biological yield was observed when vermicompost was used at lower amounts and when seed sowing was done late (Table 3). According to the present analysis, vermicompost, viaan increase of the uptake of minerals such as nitrogen and phosphorus (Arancon *et al.,* 2005; Zaller, 2007), has a positive effect on biomass production, and subsequently enhances the essence content in the seeds. In *Thymus vulgaris*, application of organic fertilizers led to a significant increase in the plant growth (Youssef *et al.,* 2004).Similarly, harvest index increased with increasing vermicompost application. The highest harvest index was related to the first planting date and 32 ton per hectare vermicompost Table 3). Seed essence percentage increased when dill seeds were sown on 3rd and 13th May and then treated with 0 or 8 ton per hectare vermicompost (Table 3). Irrespective of planting dates, the lowest essence percentage was observed in those plots which were treated with 24 or 32 ton per hectare vermicompost (Table 3).Improved essence content of medicinal plants has previously been reported in the presence of optimal amounts of vermicompost (Hadi 2011). Seed essence yield improved on account of 32 ton per hectare vermicompost and early seed sowing (13th and 23rdApril).

CONCLUSIONS

The findings of the present study suggest that application of vermicompost has promising effects on dill production. Therefore, it is recommended that vermicompost can be applied to reduce production costs and stop damage to the environment due to the use of chemical fertilizers, especially nitrogen as nitrate. In addition, the best planting dates for dill are 13th and 23rdApril.

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