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Original Article

Effects of Vermicompost and Nitrogen Fixing Bacteria on Seed Yield, Yield Components of Seed and Essential Oil Content of Coriander (*Coriandrum sativum*)

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Abstract

In order to study the effect of vermicompost and nitrogen fixing bacteria on seed yield, yield components of seed and essential oil content of coriander (*Coriandrum sativum*), 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 vermicompost in four levels (0, 3, 6 and 9 ton/ha) and nitrogen fixing bacteria (Nitroxin), mixture of *Azotobacter chroococcum* and *Azospirillum lipoferum* in two levels (non-inoculated and inoculated seeds). Inoculation was carried out by dipping the coriander seeds in the cells suspension of 10^8 CFU/ml for 15 min. The vermicompost was prepared from animal manure by employing epigeic species of *Eisenia foetida*. In this study, traits of the umbel number per plant, umberella number per umbel, weight of 1000 seeds, biomass yield, seed yield and essential oil content were evaluated. Essential oil content was determined by distilling a sample of 100 g of coriander seeds from the each plot in Clevenger's apparatus. Analysis of variance by using SAS software and mean comparisons by Duncan's Multiple Range Test (at the 5% probability level) was done. Results showed that the highest umbel number per plant, seed yield and essential oil content were obtained after applying 6 ton/ha vermicompost. The maximum umberella per umbel and biomass yield were obtained after applying 3 and 9 ton/ha vermicompost respectively. Nitrogen fixing bacteria, also showed significant effects on biomass yield and seed yield. The maximum biomass yield and seed yield were obtained by using the inoculated seeds.

Key words: *Coriandrum sativum*, Vermicompost, *Azotobacter*, *Azospirillum*, Seed yield, Essential oil

Introduction

Coriander (*Coriandrum sativum*) is an aromatic plant native to the East Mediterranean Region. Its seeds and essential oil have economical importance in the world exchanges as both medicinal and spice. The seeds contain an essential oil (up to 1%) and the monoterpenoid, linalool, is the main component. It is cultivated throughout the world including the temperate countries of central and Western Europe, the Mediterranean region (such as Turkey), North and South America, India and Iran [1-4]. Using of organic manures and biofertilizers such as vermicompost and nitrogen fixing bacteria has led to a decrease in application of chemical fertilizers and has provided high quality products free of harmful agrochemicals for human safety [5-8]. Vermicomposts are the products of the

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degradation of organic matter through interactions between earthworms and microorganisms. Vermicomposts are finely divided peat-like materials with high porosity, aeration, drainage, and water-holding capacity and usually contain most nutrients in the available forms such as nitrates, phosphates, exchangeable calcium and soluble potassium [9,10]. 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 [11,12]. The management practices by using organic manures and biofertilizers influence agricultural sustainability by improving physical, chemical and biological properties of soils and subsequently can be increased yield and essential oil of medicinal plants [13-15].

Several studies have reported that vermicompost can increase the yield and yield components of some medicinal plants such as garlic [16], plantain [17], coriander [18], fennel [14,19], chamomile [15], cumin [20], anise [21] and dill [22]. Also, some studies have reported that vermicompost can increase the essential oil content in a few medicinal plants such as basil [23-25], coriander [18], fennel [26], chamomile [15], dill [27] and anise [28].

Some other studies have reported that nitrogen fixing bacteria such as *Azotobacter chroococcum* and *Azospirillum lipoferum* could cause increased yield, yield attributes and essential oil content in a few medicinal plants such as coriander [29,30], celery [5], fennel [11,31], turmeric [32], hyssop [12], black cumin [33] and dill [22,27].

Therefore, the main objective of the present field experiment was to investigate the effects of vermicompost and nitrogen fixing bacteria on seed yield, yield components of seed and essential oil content of coriander (*C. sativum*) in order to efficient utilization from vermicompost and nitrogen fixing bacteria for suitable production of healthy seed and essential oil.

Material and 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 concentrations of vermicompost (0, 3, 6 and 9 ton/ha) and nitrogen fixing bactaria (Nitroxin), different inoculation conditions of mixture of *Azotobacter chroococcum* and *Azospirillum lipoferum* bacteria (non-inoculated and inoculated seeds). Inoculation was carried out by dipping the coriander seeds in the cells suspension of 10^8 CFU/ml for 15 min. The vermicompost was prepared from animal manure by employing epigeic species of *Eisenia foetida*. The required quantities of vermicompost were applied and incorporated to the top 5 cm layer of soil in the experimental beds before the plantation of coriander 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 vermicompost is presented in Tables1 and 2. Each experimental plot was 3 m long and 2 m wide with the spacing of 40 cm between the rows. There was a space of one meter between the plots and 2 meters between replications. Coriander seeds (an ecotype) were obtained from company of Giah-Iran, Isfahan, Iran. Sowing was done manually, 2 cm depth on 1 May 2012. There was no incidence of pest or disease on coriander 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.

Table 1 Some Traits of Physical and Chemical of the 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 Vermicompost in experiment

O.M (%)	O.C (%)	N (%)	P (%)	K (%)	pH (ds/m)	EC (ds/m)
8.5	1.8	45	26.1	11.3	0.67	3.9

Table 3 Mean comparison of the quantitative traits of coriander at various levels of Nitrogen fixing bacteria

Treatments	Umbel number per plant	Umberella number per umbel	Weight of 1000 grains (g)	Biomass yield (kg/ha)	Seed yield (kg/ha)	Essential oil content (%)
Nitrogen fixing bacteria (Nitroxin)						
b1	37.4 a	21.6 a	3.82 a	16802.3 b	2498.6 b	0.444 a
b2	38.8 a	20.5 a	4.04 a	18717.5 a	2874.8 a	0.481 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 nitrogen fixing bacteria, respectively

Measurements

Data were recorded for the umbel number per plant, umberella number per umbel, weight of 1000 seeds, biomass yield, seed yield and essential oil content. Twenty plants were randomly selected from each plot and the observations were recorded. Umbel number per plant and umberella number per umbel was recorded at the end of growth season. In addition, the weight of 1000 seeds were measured in each plot using a digital balance (Sartorius B310S; ±0.01 g). For evaluating the biomass yield, two plants were put in the oven at 80º C for 48 h and dry weight was calculated using a digital balance [34]. 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.

In order to determine the essential oil content (%), a sample of 100 g of coriander 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. The essential oil content was measured after dehydrating of water by anhydrous sodium Sulfate.

Statistical analysis

All the data were subjected to statistical analysis (one-way ANOVA) using SAS software [35]. 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 [36].

Results

Umbel number per plant

The present results have indicated that umbel number per plant was significantly affected by the application of vermicompost (Fig. 1). Among various treatments, the application of 6 ton vermicompost per hectare has indicated maximum increase in umbel number per plant (42.5). Nitrogen fixing bacteria did not show significant effect on this trait (Table 3).

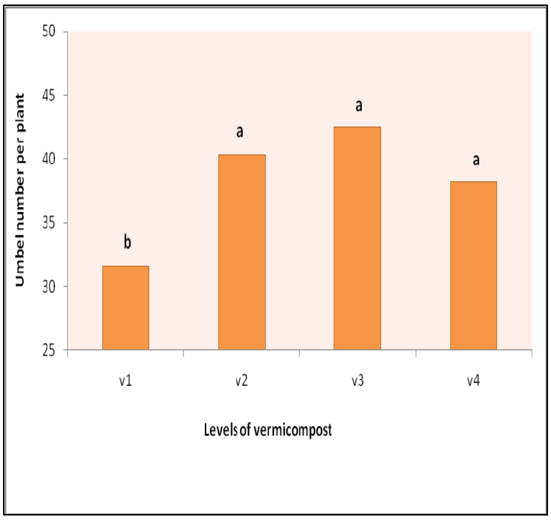

Fig. 1 Mean comparison for umbel number per plant in different levels of vermicompost
v1, v2, v3 and v4 represent 0, 3, 6 and 9 ton vermicompost per hectare, respectively.

Umberella number per umbel

The results indicated that umberella number per umbel was not affected by vermicompost and nitrogen fixing bacteria (Fig. 2 and Table 3). However, the application of 3 ton/ha vermicompost caused more umberella number per umbel (23.5).

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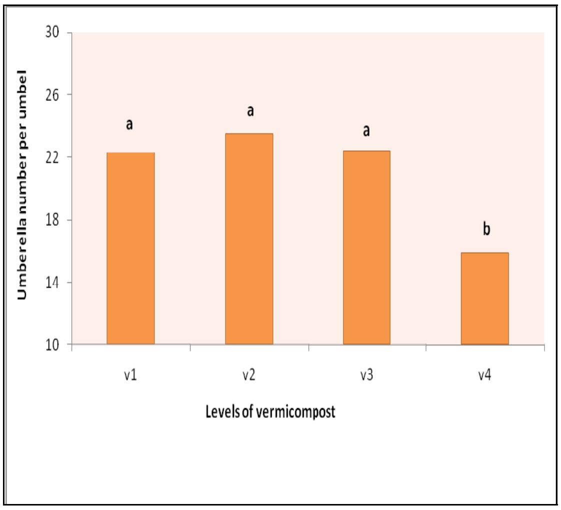

Fig. 2 Mean comparison for umberella number per umbel in different levels of vermicompost

Weight of 1000 seeds

The results indicated that weight of 1000 seeds was not affected by vermicompost and nitrogen fixing bacteria (Fig. 3 and table 3).

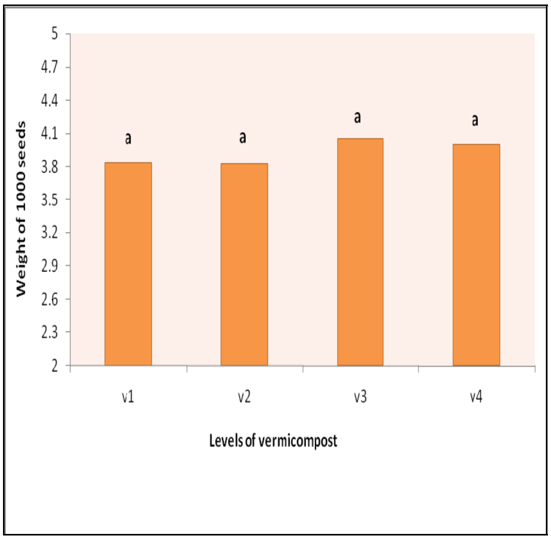

Fig. 3 Mean comparison for weight of 1000 seeds in different levels of vermicompost

Biomass yield

The results have indicated that biomass yield was affected by the application of vermicompost (Fig. 4). Significant increase in biomass yield was observed in three treatments of vermicompost application (3, 6 and 9 ton/ha) as compared to the control experiment (non-vermicompost). The highest biomass yields were obtained with applying 9 ton/ha vermicompost (19924 kg/ha).

Biofertilizer showed significant effect on biomass yield (Table 3), as the highest biomass yield (18717.5 kg/ha) was obtained in the second treatment level of nitrogen fixing bacteria (inoculated seeds).

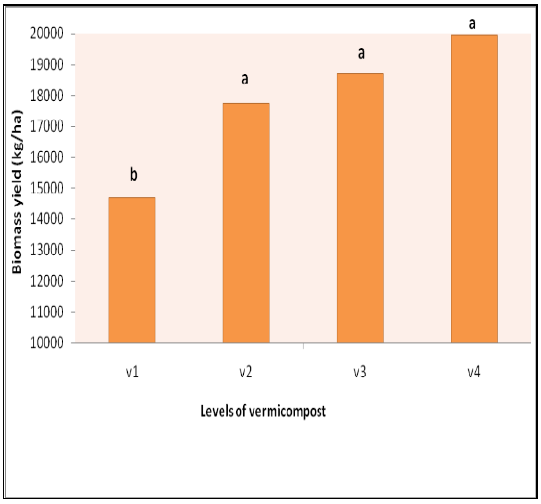

Fig. 4 Mean comparison for biomass yield in different levels of vermicompost

Seed yield

The results presented in Fig. 5 have revealed that various levels of vermicompost had significant effects on the seed yield. The maximum seed yield (3268.6 kg/ha) was obtained by using 6 ton vermicompost per hectare. Significant increase in seed yield was observed in treatment of biofertilizer application (inoculated seeds by nitrogen fixing bacteria) as compared to the control (Table 3). The highest seed yield (2874.8 kg/ha), however, was found after application of nitrogen fixing bacteria (mixture of *Azotobacter chroococcum* and *Azospirillum lipoferum*).

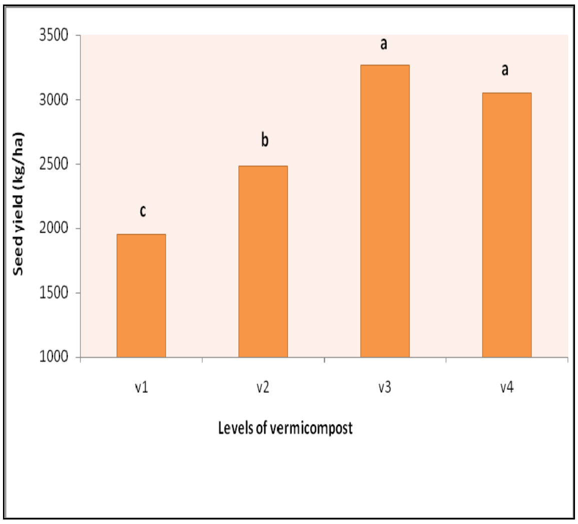

Fig. 5 Mean comparison for seed yield in different levels of vermicompost

Essential oil content

The present results have indicated that essential oil content was significantly affected by the application of vermicompost (Fig. 6). The most significant essential oil content (0.536%) was obtained by applying 6 ton vermicompost per hectare. Biofertilizer did not show significant effect on essential oil content (Table 3).

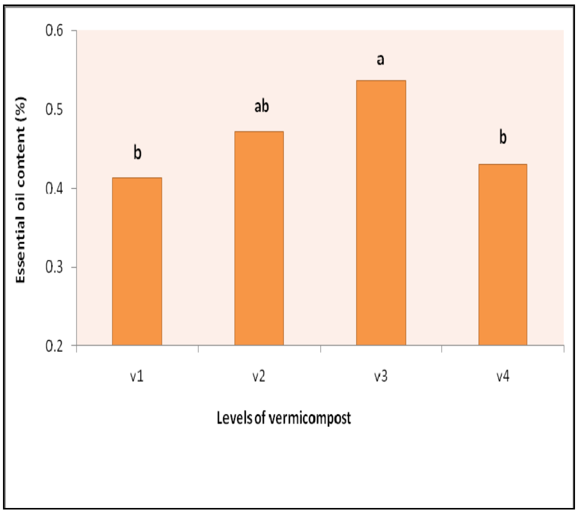

Fig. 6 Mean comparison for essential oil content in different levels of vermicompost

Discussion

Vermicompost application through the improvement of biological activities of soil and mineral element absorption [37,38], caused more biomass production and subsequently enhanced umbel number per plant. Saeid Nejad and Rezvani Moghaddam [20] reported a large number of umbel of cumin in response to 10 ton/ha vermicompost application. They have suggested that vermicompost affected the umbel number through gradual mineralization of soil and improvement of vegetative growth. Our finding is in accordance with the observations of Pandey [39] on *Artemisia pallens* Wall. Ex DC, Moradi *et al.* [19] on *Foeniculum vulgare* Mill. and Darzi *et al.* [21] on *Pimpinella anisum* L.

Vermicompost increases the growth rate because of the water and mineral uptake such as; nitrogen and phosphorus [38,40], which leads to the biomass yield improvement. This finding is in accordance with the previous observations [19-22,24]. Effect of nitrogen fixing bacteria on the biomass yield was due to increased nitrogen uptake [7, 11]. The result of present work are in agreement with the reports of Swaminathan *et al.* [41] and Kumar *et al.* [8] on *A. pallens*, Valadabadi and Farahani [33] on *Nigella sativa* L. and Darzi and Haj Seyed Hadi [22] on dill.

Increased seed yield in vermicompost treatments can be owing to the improvement of yield components such as; umbel number per plant and biomass yield. Our findings are in accordance with the observations of Saeid Nejad and Rezvani Moghaddam [20], Sanchez *et al.* [17], Singh *et al.* [18], Moradi *et al.* [19] and Darzi and Haj Seyed Hadi [22]. Whilst, Arguello *et al.* [16] demonstrated that increased supply of mineral elements, through vermicompost application, resulted in greater absorption and utilization of these elements, which resulted in better yield of garlic due to an earlier start of bulbification and lengthening of the bulb filling period. Darzi *et al.* [21] have shown that the application of 5 and 10 ton/ha vermicompost on *P. anisum* caused greater seed yield as compared to the experimental plants with no vermicompost application due to an earlier start of growth and lengthening of the grain filling period. Nitrogen fixing bacteria, promoted seed yield through the enhancement of yield attributes . These result are in agreement with the investigation of Kumar *et al.* [29] on *C. sativum*, Migahed *et al.* [5] on *Apium graveolens* L., Abdou *et al.* [31] on *F. vulgare*, Valadabadi and Farahani [33] on *N. sativa* and Darzi and Haj Seyed Hadi [22] on *Anethum graveolens* L. Mahfouz and Sharaf Eldin [11] demonstrated that increased supply of mineral nitrogen, through nitrogen fixing bacteria application, resulted in greater absorption and utilization of this element, which resulted in better growth of fennel plant having direct effect on the yield attributes as well as the grain yield.

Vermicompost application through increase of the mineral uptake such as; nitrogen and phosphorus [38, 40], has a positive effect on proper biomass production and subsequently the enhanced essential oil content. Improved essential oil content of medicinal plants have previously been reported in the presence of optimal amounts of vermicompost [15,18,25-27]. Anwar *et al.* [24] found that the application of 5 ton/ha vermicompost on *Ocimum basilicum* caused greater essential oil content as compared to control. They demonstrated that vermicompost addition to soil through improvement of root growth and greater absorption of mineral elements which leads to the increased essential oil content. Haj seyed Hadi *et al.* [15] stated that organic matters such as vermicompost can improve soil structure, improving root development, providing plant nutrients and enhancing nutrient uptake by chamomile plants.

Moreover, vermicompost facilitates water absorption and retention by the soil, which has a favorable effect on growth and essential oil content of chamomile.

Conclusions

It is clear from the present study that vermicompost and nitrogen fixing bacteria successfully manipulate the growth of coriander, resulting in beneficial changes in yields. The highest seed yield and essential oil content was obtained by using 6 ton vermicompost per hectare. Maximum seed yield was observed by using nitrogen fixing bacteria application (inoculated seeds). Thus, combined application of vermicompost and nitrogen fixing bacteria (azotobacter + azospirillum) can be helpful in the development and production in coriander.

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