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Effects of biological and chemical fertilizers nitrogen on yield and yield components in cumin (*Cuminum cyminum* L.)

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Abstract

Considering the importance of medicinal plants growth and biological application of fertilizers with sustainable agricultural production in order to eliminate or reduce chemical input to achieve desirable and sustainable quality, an experimental research was conducted based on a randomized complete block design with two factors of chemical nitrogen (46% urea nitrogen) at two levels (0, 25 and 50 kg/ha^{-1}), biological nitrogen (combination of *Azotobacter* spp. and *Azospirillum* spp.) at two levels inoculated and non-inoculated in 2010. The results of analysis of variance showed that the effects of biological nitrogen (combination of *Azotobacter* spp. and *Azospirillum* spp.) of chemical nitrogen (urea 46%) in different treatments on plant height, umbel number per plant, grain number per umbel and grain yield were significant at P≤0.01. However, there were no significant differences between treatments in about weight of 1000 grains and grain number per plant. The results showed that the greatest plant highest (28.18 cm) and grain yield (75.600 g/m^2) and were obtained by a treatment of biological nitrogen + chemical nitrogen (25 kg/ha^{-1}). Results indicate that applying the combined biological nitrogen and chemical nitrogen fertilizer can be practical and helpful method to increase Cumin yield, yield components and reduce the environmental pollution.

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Introduction

Medicinal plants have a special place in traditional Iranian medical science. Such plants are frequently used in people's everyday lives and are important for the treatment of a variety of diseases (Riaz *et al.* 1996). Approximately 80% of the world population depends on medicinal plants for their health and healing (Aliyu. 2003). Societal motivations to use herbs are increasing due to concern about the side effects of synthetic drugs. Many botanicals and some dietary supplements are good sources of antioxidants and anti-inflammatory compounds (Balasubramanian and Palaniappan. 2001). Cumin (*Cuminum cyminum* L.) is aromatic plant within the Apiaceae family that use in foods, fragrances, and medical preparations (liqueurs, mouthwashes, toothpastes, soaps, and perfumes). They are used as antispasmodic, carminative, and appetite stimulating agents (Iacobellis *et al.* 2005; Morton, 1976). Cumin is regularly used as a flavoring agent in a number of ethnic cuisines. Cumin seeds have been found to possess significant biological activities, such as antibacterial (Morton. 1976), antifungal, anti-carcinogenic (Gagandeep *et al.* 2003), anti-diabetic, anti-thrombotic (Ferrie *et al.* 2011), and antioxidant properties (Ferrie *et al.* 2011; Thippeswamy and Akhilender. 2005). Nitrogen fertilization management is important to optimize crop production. Nitrogen is one of the most important nutrients in crop production, because it affects photosynthetic efficiency and leaf development, which leads to dry matter production (Dordas and Sioulas, 2008). There are some supporting studies that nitrogen fertilization affects yield, content, and composition of essential oils of medicinal plants (Ashraf *et al.* 2001). However, nitrogen application presents conflicting results in regards to growth, essential oil yield and contents of medicinal plants Economakis *et al.* (1999) showed that nitrogen fertilization had no effect on essential oil content of *Origanum dictamnus*. Biological nitrogen (*Azotobacter*) absorbed and increased the concentration of essential elements such as nitrogen, phosphorus, potassium, zinc, magnesium, iron, and protein in crops (Habibi *et al.* 2004). Research has shown that the performance and the ability of *Azotobacter* in nitrogen fixation and balance in the soil depend on the soil properties and plant (Requena *et al.* 1997). Despite the significant positive effects of *Azotobacter* on plants, the exact function in the development of plant growth is still unknown. Pereira *et al.* (1998) in their studies on inoculated pearl millet announced the increased performance by more than 33%. Research has shown that the effect of biological *Azatobacter* fertilizer was significant on pepper, and the highest pepper yield was reported 3.34 ton.ha^{-1} (Mandel *et al.* 2003). Nitrogen improved the performance of more than 30% of Geranium (Pelargonium) and other medicinal plants (Rao *et al.* 1998). Application of 100 kg.ha^{-1} of nitrogen increased the production of secondary metabolites (*Cisque Terpin*) and percentage chamomile (*Matricaria chamomilla*) increased dry matter from 3 to 6% (Bullock, 1999). Also, the effect of nitrogen on dry weight and percent *Thymus Kotschyanus* species was significant but left no significant impact on the amount and percentage of oil and *carvacrol* (Habibi *et al.* 2004). Research showed that the amount of nitrogen up to 120 kg.ha^{-1} produced more *thymol* yield in *thyme* oil but there was no significant effect on the amount of seed oil (Akbari niea *et al.* 2004). Nitrogen increased *thymus vulgaris* oil yield and percent *thymol* and the best treatment was 100 kg N.ha^{-1} (Rezaei Nejad *et al.* 2000). Research showed that by increasing nitrogen application from 105 to 120 kg.ha^{-1}, the essence yield and *thymol* increased significantly but there was no significant effect on the amount of seed oil (Akbari niea *et al.* 2004). The present investigation was done in order to evaluate the effect of different treatments methods of biological nitrogen and chemical nitrogen fertilizer on yield and yield components of Cumin (*Cuminum cyminum* L.) medicinal plant.

Materials and methods

Experimental location condition

The experiment was carried out in 2010 at the agricultural research farm of faculty of agriculture and natural resources at Shahed University, Tehran, Iran (48' 53° E and 31' 36° N of 1050 meters above

sea level). The climate of the locations was semi-arid region; 259 mm (mean annual precipitation). The physical and chemical properties of the experimental soil where shown in Table 1. The field was prepared in autumn and in March, the crop was planted.

Experimental design and field preparing

The experiment was factorial with two factors arranged in a randomized complete block design with three replications. The first factor was three levels of chemical nitrogen fertilizer (46% urea nitrogen) 0, 25 and 50 kg/ha^{-1} and second factor was biological nitrogen fertilizer (combination of *Azotobacter* spp. and *Azospirillum* spp.) at two levels; inoculated and non-inoculated. Each experimental plot was three meters long and two meters wide with the spacing of 30 cm between the rows. There was a space of one meter between the plots and two meters between replications. The Cumin seeds were planted distance were one centimeter apart, covered with wet sand and about a centimeter thick and after emerging from the soil, thinning operation to set the desired density was performed. Biological nitrogen fertilizer (combination of *Azotobacter* spp. and *Azospirillum* spp.) solution was applied as sprinkling system. Three-quarters of fertilizer was applied at planting seeds and the rest was applied to plant at shooting. Cumin seeds were directly sown by hand. There was no incidence of pest or disease on cumin during the experiment. Basin irrigation until harvest was done depending on weather conditions and weeds were controlled. In order to measurement of characteristics of effective on yield components and substance effective, 10 plants from each plot were harvested randomly after removing the marginal effects of each plot. All necessary cultural practices and plant protection measures were followed uniformly for all the plots during the entire period of experimentation.

Experimental Analysis

Data analysis was done by using software SPSS and MSTAT-C. The ANOVA test was used to determine significant ($p \leq 0.01$ or $p \leq 0.05$) treatment effect and Duncan Multiple Range Test to determine significant difference between individual means.

Studied factors

In this experiment plant height, umbel number per plant, grain number per plant, grain number per umbel, grain yield and weight of 1000 grains were studied. Fifteen plants were randomly selected from each plot and the observations were recorded. The present investigation was done in order to evaluate the effect of different treatments methods of biological and chemical fertilizers nitrogen on yield and yield components in Cumin (*Cuminum Cyminum* L.).

Results and discussion

Plant height

The results of the analysis variance showed that the plant height was significantly affected by treatments ($P \leq 0.01$) in this experiment (Table 2). Mean comparison table showed that the highest (28.1 cm) and lowest (15.6 cm) plant height were obtained by a treatment of biological nitrogen + chemical nitrogen (25 kg.ha^{-1}) and control, respectively (Table 3). According to the present analysis, biological nitrogen increased plant height by enhancing the nitrogen content and the rate of photosynthesis (Fatma *et al.* 2006). The current results were derived from the improvement of nitrogen fixing bacteria activities in soil, which correlates to the previous studies carried out on the fennel, cerely, black cumin and hyssop (Koocheki *et al.* 2006; Migahed *et al.* 2004; Shaalan, 2005; Tehlan *et al.* 2004).

Table 1. Physical and chemical properties of studied experimental soil.

Soil T	O.C (%)	EC ds/m	pH	K ppm	P ppm	N ppm
Sandy loam	0.34	2.17	7.8	150	3.2	0.037

Umbel number per plant

The results indicated that umbel number per plant was significantly affected by treatments ($P \leq 0.01$) in this experiment (Table 2). Mean comparison table showed that the highest (21.2) and lowest (14.7) umbel number per plant were obtained by a

treatment of biological nitrogen + chemical nitrogen (25 kg.ha^{-1}) and control, respectively (Table 3). Biological nitrogen has significantly influenced the umbel number per plant. On the other hand, nitrogen fixing bacteria application through the improvement of biological activities of soil and mineral element absorption caused more biomass production and umbel number per plant. These findings are in accordance with the observations by Tehlan *et al.* (2004) on *Foeniculum vulgare*, Migahed *et al.* (2004) on *Apium graveolens*, Shaalan (2005) on *Nigella sativa* and Darzi *et al.* (2001) on *Coriandrum sativum*.

Table 2. Analysis of variance for the Effects of biological and chemical fertilizers nitrogen on yield and yield components in Cumin (*Cuminum Cyminum* L.).

Resource changes	df	Plant height	Umbel number per plant	Grain number per plant	Grain number per umbel	Weight of 1000 grains	Grain yield
Repetition	2	15.870 ^{ns}	18.141 ^{ns}	1.562 ^{ns}	1.383 ^{ns}	13.802 ^{ns}	121.295 ^{ns}
Biological nitrogen (A)	1	1.033 **	197.884 **	5.210 **	0.683 ^{ns}	0.440 ^{ns}	2715.021 **
Chemical nitrogen (B)	2	0.593 **	63.479 **	16.027 **	0.138 ^{ns}	0.093 ^{ns}	4782.342 **
A × B	2	4.481 **	106.224 **	1.069 **	0.648 ^{ns}	1.697 ^{ns}	375.964 **
Error	10	2.459	2.433	0.367	0.400	0.553	9.049
CV (%)	-	8.76	8.93	8.00	21.07	13.11	5.07

**: Significant at = 1%, ns: Not significant.

Grain number per plant

The results of ANOVA showed that the effect of treatments on grain number per plant was not significant (Table 2). The mean comparison of data in different treatments (Table 3) showed that the highest grain number per plant (3.1) was determined by biological nitrogen + chemical nitrogen (25 kg.ha^{-1}). The lowest grain number per plant (2.7) was obtained in control plants. This result showed the positive effect of biological fertilizer on grain number per plant**.** Similar results were observed in some plants such as *Ammi visnaga* and *Salvia officinalis* (Abd El-Latif, 2006; Shaalan, 2005).

Table 3. Mean comparison of the effect of biological and chemical fertilizing systems on yield and yield components of cumin.

Treatments	Grain yield (g.m^2)	Umbel number per plant	Grain number per plant	Grain number per umbel	Weight of 1000 grains (g)	Plant height (cm)
N1+	58.961 c	16.771 c	3.051 a	7.051 d	5.890 a	19.045 c
N2+	75.600 a	21.244 a	3.180 a	8.494 a	5.919 a	25.184 a
N3+	53.472 d	15.109 d	2.999 a	7.897 bc	5.634 a	20.740 b
N1-	40.867 e	14.701 d	2.712 a	6.666 e	5.378 a	15.610 b
N2-	68.433 b	18.394 b	3.083 a	8.322 ab	5.551 a	24.256 a
N3-	58.294 c	18.479 b	2.977 a	7.278 cd	5.695 a	20.404 b

Treatments with at least one letter in common show no significant difference. N-: no inoculation, N+: inoculation with biological nitrogen: N1:0, N2: 25,N3: 50 (kg.ha^{-1}) chemical nitrogen.

Grain number per umbel

Analysis of variance (ANOVA) of data showed that the effect of by treatments were significant at 1% probability level (Table 2). Mean comparison table showed that the highest (8.4) and lowest (6.6) grain number per umbel were obtained by a treatment of biological nitrogen + chemical nitrogen (25 kg.ha^{-1}) and control, respectively (Table 3). Effect of biological

nitrogen on the grain number per umbel of plant was due to increased nitrogen uptake and growth rate improvement (Vande Broek, 1999). The results of this experiment are similar to the reports of Youssef *et al.* (2004) on *Salvia officinalis* and Valadabadi and Farahani (2011) on *Nigella sativa*.

Weight of 1000 grains

The results showed that treatments did not have a significant effect on weight of 1000 grains (Table 2). Mean comparison table showed that the highest (5.9 gr) and lowest (5.3 gr) weight of 1000 grains were obtained by a treatment of biological nitrogen + chemical nitrogen (25 $kg.ha^{-1}$) and control, respectively (Table 3). Biological nitrogen increased the weight of 1000 seeds by the biomass production improvement (Roy and Singh, 2006). The results are similar to the report of Darzi *et al.* (2001) on fennel.

Grain yield

The results presented in Table 2 indicate that different levels of treatments had significant effects on the grain yield ($P \leq 0.01$). Mean comparison table showed that the maximum (75.6 $g.m^2$) and minimum (40.8 $g.m^2$) grain yield were obtained by a treatment of biological nitrogen + chemical nitrogen (25 $kg.ha^{-1}$) and control, respectively (Table 3). Increased seed yield in biological nitrogen treatments may be due to the improvement of yield components such as; umbel number per plant, grain number per plant and grain number per umbel of plant. These result correlate to the investigation of Kumar *et al.* (2002) and Darzi *et al.* (2001) on *Coriandrum sativum*, Migahed *et al.* (2004) on *Apium graveolens*, Tehlan *et al.* (2004), Shaalan (2005) and Valadabadi and Farahani (2011) on *Nigella sativa*.

Conclusion

Biological fertilizers are widely applied in crop production and they are proper substitutions for chemical fertilizers. The application of biological fertilizer significantly improved the yield and yield components in cumin. Maximum of plant height, umbel number per plant, grain number per umbel and grain yield was obtained in the treatment of biological nitrogen + chemical nitrogen (25 $kg.ha^{-1}$). The obtained results revealed that using biological fertilizer combined with chemical fertilizer significantly improved the quantity and quality characters compared to the control group.

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