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Effect of biological nitrogen and chemical nitrogen fertilizer on yield quality and quantity of cumin (*Cuminum cyminum* L.)

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Abstract

In order to study the effect of biological nitrogen and chemical nitrogen on yield quality and quantity of cumin (*Cuminum cyminum* L.), this asymmetrical factorial experiment was arranged in randomized complete block design (RCBD) with three replications at the agricultural research farm of Shahed University in the growing season of 2010. Studied factors included two levels of biological nitrogen (no inoculation (-) and inoculation (+)) and three levels of chemical nitrogen (0 (N1), 25 (N2), and 50 (N3) $kg.ha^{-1}$). The obtained results indicated that biological nitrogen effect on some of the studied characteristics was significant and even competitive with that of chemical nitrogen. The highest seed yield (75.6 $g.m^2$), biological yield (201.1 $g.m^2$), harvest index (37.0 %) and essential oil yield (2.1 $g.m^2$) were recorded in the interaction of biological nitrogen and chemical nitrogen at the level of 50 $kg.ha^{-1}$. The lowest seed yield (40.8 $g.m^2$), biological yield (148.7 $g.m^2$), harvest index (27.9%) and essential oil yield (1.1 $g.m^2$) were obtained from the control treatment. However, there were no significant differences between treatments in about essential oil percentage. Finally, it was shown that biological nitrogen significantly improved quantitative and qualitative yields of cumin, therefore, could be considered as an appropriate fertilizing system in reducing the application of chemical nitrogen.

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Introduction

Application of chemical fertilizers has many environmental hazards such as soil and water contamination and can endanger human health (Rahmani, 2010). Application of soil microorganisms as biological fertilizer is considered as the most natural and efficient solution for sustaining and activating soil bacterial life (Saleh Rastin, 2001). ergy with rhizobia, biological fixation of nitrogen (Ishizuka, 2002), and production of antibiotic agents, such as bacteriocins, for controlling plant disease agents (Tapia hemande *et al.*, 1990). Consumption of biological fertilizers is considered as the most efficient soil management method to sustain soil quality at a favorable level (Kokalis *et al.*, 2006). Generally, biological fertilizers are microbial inoculants that induce nutrient availability through their biological mechanism. Biological fertilizers have been used as environmental-friendly inputs since the last decade. This resulted in reduction of the application of chemical fertilizers and improvement of soil fertility through biological activity in rhizosphere area (Mohammad Verzi *et al.*, 2010). 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.*, 2006). 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*. Cumin (*Cuminum cyminum* L.) is regarded as the most important medical herb in the country. It is a small and annual umbelliferous plant (Moraghebi *et al.*, 2008) that has a short growing season, low water consumption, and a relatively high resistance to environmental tensions (Kafi, 2002). Its aromatic seeds have medical applications and contain 7% essential oil, 13% resin, 2.5 to 4% essence and aleurone (Saeidnezhad and Rezvani-Moghadam, 2009). It can be used in curing indigestion and dyspepsia and for increasing milk. It was also shown that cumin can affect gram-positive bacteria (Ani *et al.*, 2006). A research studying fennel (*Foeniculum vulgare* Mill.) showed that the application of bio-fertilizer increased umbels, biological yield, and seed yield (Darzi *et al.*, 2008). Another research studying the effect of biological and chemical phosphorus fertilizers on yield and yield components of fennel showed that inoculation with bio-fertilizer increased the number of umbels and clusters, plant and total dry biomass, and essential oil yield (Ramezani, 2009). In the study of essential oil yield and chamazulene percentage in German chamomile (*Matricaria recutita* L.) the highest values were recorded in the interaction of 40 $kg.ha^{-1}$ chemical fertilizer and bio-fertilizer (Alijani *et al.*, 2011). Annamalai *et al.*, (2004)_reported that the application of bio-fertilizer significantly increased the biological yield of a medical plant belonging to Euphorbiaceae family (phyllanthus amarus) in comparison with the control treatment. Studying sugar cane (*Saccharum officinarum*), Sandra *et al.*, (2002) also showed that the application of a particular species of bio-fertilizer along with phosphate stone increased the quantity and quality of sucrose in comparison with the control treatment. Regarding the necessity researches on the use of the alternative methods for chemical fertilization and the limited researches on the effect of bio-fertilization in Iran's medical plants on one hand and the economic and medical importance of cumin on the other hand, this experiment was conducted to study the effect of biological nitrogen and chemical nitrogen (46% urea nitrogen) on yield quality and quantity of cumin.

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). Regarding the climatic conditions of the experimental site, seedbed preparation started in March 2010 (Annual Meteorological Statistics of Tehran, 2010). A soil sample was collected in a zigzag pattern from the depth of 30 cm to determine the chemical and physical properties of the soil (Table 1).

Experimental design and field preparing

This asymmetrical factorial experiment was arranged in randomized complete block design (RCBD) with three replications. Sowing was done in a linear pattern in March 2010. The designed plots were 3 m long and 2 m wide and consisted of 6 lines. There was a 1 m space between the plots and a 3 m space between the replications. There was a 2 cm space between the plants and a 20 cm space between the rows. Studied factors included two levels of biological nitrogen [no inoculation (-) and inoculation (+)] and three levels of chemical nitrogen [0 (N1), 25 (N2), and 50 (N3) $kg.ha^{-1}$] applied as a thin strip 4 cm away of the seeds. 40 g seed were collected from each treatment and ground into powder. The essential oil was obtained through hydro distillation of the powder using a Clevenger type apparatus for 3h at 100°C. The essential oil percentage was multiplied by seed yield to obtain essential oil yield. The two border lines and 0.5 m of both ends were discarded in each plot as border effect and the remaining area was harvested to obtain seed yield, biological yield, and harvest index.

Experimental Analysis

After sampling and measuring the characteristics, the obtained data was subjected to statistical analysis according to statistical model of factorial experiments using MSTAT-C and SPSS statistical software packages (Table 2). Means were compared using Duncan's multiple range test (Table 3). Microsoft Office Word and Excel were employed to design the tables and draw the charts.

Results and discussion

Seed yield

The results presented in Table 2 indicate that different levels of treatments had significant effects on the seed yield ($P \leq 0.01$). Mean comparison table showed that the maximum (75.6 $g.m^2$) and minimum (40.8 $g.m^2$) seed yield were obtained by a treatment of biological nitrogen + chemical nitrogen (25 kg/ha^{-1}) and control, respectively (Table 3). Bio-fertilizers can also provide plants with soluble nutrients through the secretion of solubilizing bacteria and decrease of soil's acidity (Rademacher, 1994). The results obtained by Mirshekari *et al.*, (2007) indicated that the simultaneous presence of bio-fertilizers and micronutrients would show the highest effect on increasing seed yield in cumin. Congruently, the results obtained by Gad (2001) showed that the application of bio-fertilizers is necessary for increasing growth and seed yield in fennel and dill. Another study on fennel also revealed that the application of bio-fertilizer would lead to the increase of the number of umbels in plant, biological yield, and seed yield in comparison to the control (Darzi *et al.*, 2008).

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

Biological yield

The results of the analysis variance showed that the biological yield was significantly affected by treatments ($P \leq 0.01$) in this experiment (Table 2). Mean comparison table showed that the highest (201.1 $g.m^2$) and lowest (148.7 $g.m^2$) biological yield 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 biological yield of plant was due to increased nitrogen uptake and the growth rate improvement (Vande Broek, 1999). The result of this study is similar to the reports of Youssef *et al.*, (2004) on *Salvia officinalis*, Kumar *et al.*, (2002) on *Artemisia* *pallens* and Valadabadi and Farahani (2011) on *Nigella sativa*.

Harvest index (HI)

The results of the analysis variance showed that the harvest index was significantly affected by treatments (P≤0.01) in this experiment (Table 2). Mean comparison table showed that the highest (37.0 %) and lowest (27.9 %) harvest index were obtained by a treatment of biological nitrogen + chemical nitrogen (25 $kg.h^{-1}$) and control, respectively (Table 3). The same result was observed in a study on the effects of application of biological fertilizer on biological yield and growth indices of black cumin (Khoram *et al.*, 2008). Results showed 22.8% partitioning of photosynthetic was appropriated for grain and the rest for straw. The grain and the vegetative plant and improvements in harvest index emphasized the importance of carbon allocation in grain production. However, increasing grain yield and crop harvest index with high nitrogen grain requires a concomitant increase in crop nitrogen accumulation (Sinclair, 1998).

Table 2. Analysis of variance for the effect of biological and chemical fertilizing systems on yield quality and quantity of cumin.

Resource changes	df	Seed yield	Biological yield	Harvest index (HI)	Essential oil percentage	Essential oil yield
Repetition	2	121.295 ^{ns}	608.183 ^{ns}	14.500 ^{ns}	4.020 ^{ns}	1.819 ^{ns}
Biological nitrogen (A)	1	2715.021 **	5208.333 **	365.486 **	0.130 ^{ns}	1.552 **
Chemical nitrogen (B)	2	4782.342 **	9238.695 **	472.421 **	0.053 ^{ns}	3.985 **
A × B	2	375.964 **	1265.298 **	76.136 **	0.146 ^{ns}	0.491 **
Error	10	9.049	61.914	2.789	0.130	0.055
CV (%)	-	5.07	4.45	5.10	11.161	14.07

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

Essential oil percent

The results showed that treatments did not significantly affect the essential oil percentage (Table 2). Mean comparison table showed that the highest (3.2 %) and lowest (2.9) essential oil percentage were obtained by a treatment of biological nitrogen + chemical nitrogen (25 kg/ha^{-1}) and control, respectively (Table 3). Plant ecotype differences in regional environmental, soil, and climatic conditions, growing techniques, irrigation, as well as fertilization affected the content and composition of secondary metabolites in medicinal and aromatic plants (Ashraf *et al.*, 2006). There are studies that support the notion that nitrogen fertilization affects content and composition of secondary metabolites in medicinal plants (Ozguven *et al.*, 2006).

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

Treatments	Seed yield ($g.m^2$)	Biological yield ($g.m^2$)	Harvest index (%)	Essential oil percentage	Essential oil yield ($g.m^2$)
N1+	58.961 c	172.922 c	32.934 c	3.046 a	1.658 b
N2+	75.600 a	201.178 a	37.092 a	3.200 a	2.115 a
N3+	53.472 d	176.868 c	28.024 d	3.172 a	1.554 b
N1-	49.867 e	148.767 d	27.926 d	2.995 a	1.150 c
N2-	68.433 b	185.578 b	36.734 a	3.097a	1.984 a
N3-	58.294 c	176.770 bc	33.696 bc	3.117 a	1.635 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.

Essential oil yield

The results of the analysis variance showed that the essential oil yield was significantly affected by treatments (P≤0.01) in this experiment (Table 2). Mean comparison table showed that the highest (2.1 g.m^2) and lowest (1.1 g.m^2) essential oil yield were obtained by a treatment of biological nitrogen + chemical nitrogen (25 kg/ha^{-1}) and control, respectively (Table 3). Although the effective elements of plants are produced by genetic processes, their production is affected by different factors such as: yield loss, wrong management and particularly nutrients deficit (Malakouti and Motasharihzaeh, 2009). The results of this study confirm the results of Azizi (2000) on the effect of nitrogen on the essence yield in anis plant. Shalaby and Razin (1992) reported that application of 105 kg.ha^{-1} of nitrogen increased essence and *thymul* in *Thymus* plant.

Conclusion

The obtained results indicated that the interaction of biological nitrogen and 50% of required chemical nitrogen increased essence yield percentage, biological yield, seed yield, harvest index and essential oil yield. Therefore, regarding the reduction of application of chemical fertilizers for promoting sustainable agriculture, it can be concluded that biological fertilizer can supply a large part of the required nutrients in cumin.

References

Alijani M, Amini Dehaghi M, Malbobi MA, Zahedi M, Sanavi AM. 2011. The effect of interaction between different levels of phosphorus chemical fertilizer and Barvar-2 phosphate bio-fertilizer on yield, essence yield and chamazulene percentage in German chamomile (*Matricaria recutita* L.). Iranian Journal of Medical and Aromatic Plants **27(3),** 450-459.

Ani V, Varadaraj MC, Akhilender K. 2006. Antioxidant and antibacterial activities of polyphenolic compounds from bitter cumin (*Cuminum nigrum* L.). European Food Research and Technology; **224(1),** 109-150. http://dx.doi.org/101007/s00217-006-0408-8.

Annamalai A, Lakshmi PTV, Lalithakumari D, Murugesan K. 2004. Optimization of biofertilizers on growth, biomass and seed yield of Phyllanthusamarus (Bhumyamalaki) in sandy loam soil. journal of medicinal and aromatic plant sciences. **26,** 21-28.

Ashraf M, Qasim A, Zafar I. 2006. Effect of nitrogen application rate on the content and composition of oil, essential oil and mineral in black cumin (*Nigella sativa* L.) seeds. Journal of the Science of Food and Agriculture **86,** 871–876.

Azizi SJ. 2000. Effect of nitrogen on the essence yield in anis plant. Agricultural Sciences **3(123),** 88-79.

Darzi M, Ghalavand TA, Rajali F. 2008. Studying the effect of mycorrhiza, vermicomposting, and phosphate bio-fertilizing on flowering, biological yield, and root symbiosis in fennel. Iranian Agronomical Sciences Journal **10(1),** 88-109.

Dordas CA, Sioulas C. 2008. Safflower yield, chlorophyll content, photosynthesis, and water use efficiency response to nitrogen fertilization under rainfed conditions. Industrial Crops and Products. **27,** 75–85.

Economakis C, Demetzos C, Anastassaki T, Papazoglou V, Gazouli M, Loukis A, Thanos CA, Harvala C. 1999. Volatile constituents of bracts and leaves of wild and cultivated *Origanumdictamnus* L. Planta medicinal **65,** 89–191.

Gad WM. 2001. Physiological studies on Foeniculum vulgare and Anethum graveolense M.Sc. Thesis. Faculty of Agriculture, Kafr EL Sheikh, Tanta University, Egypt.

Ishizuka L. 2002. Trends in biological nitrogen fixation research and application. Plant and Soil. **11,** 197-209.

Kafi M. 2002. Green cumin, production and processing. Ferdowsi University of Mashhad, Mashhad.

Khoram S, Kocheki A, Mahlati MN, Ghorbani R. 2008. Application effects of biofertilizers on the growth indices of black cumin (*Nigella sativa* L.). iranian journal of field crops research **6(2),** 285-293.

Kloepper JW, Lifshitz K, Schroth MN. 1998. Pseudomonas inoculants to benefit plant production. Plant Science **1,** 60-64.

Kokalis Burelle N, Kloepper JW, Reddy MS. 2006. Plant growth promoting Rhizobacteria and transplant amendments and their effects on indigenous Rhizosphere microorganisms. Applied Soil Ecology **31,** 91-100.

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

Malakouti M, Motasharihzaeh J. 2009. Role in increasing the quantitative and qualitative improvement of agricultural, Publication Agricultural Education, Karaj.

Mirshekari B, Asadi Rahmani H, Mirmozatari Roodsari A. 2009. The effect of seed inoculation with azospirillum bacteria and micronutrients on seed yield and essence yield of cumin. Iranian Journal of Medical and Aromatic Plants **25(4),** 470-481.

Mohammad Verzi R, Habibi D, Vazan S, Pazoki AR. 2010. The effect of growth stimulant bacteria (PGPR) and nitrogen fertilizer on yield and yield components of sunflower. Iranian National Conference on New Ideas in Agriculture. 175-181 P.

Moraghebi F, Teimoori M, Sahebi AR. 2008. The effect of fertilization on the chemical components and anti-microbial property of cumin essence. Journal of Plant and Environment **23(1),** 34-37.

Ozguven M, Ayanglu F, Ozel A. 2006. Effect of nitrogen rates and cutting times on the essential oil yield and components of *Origanum syriacum* L. var. bevanii. Journal of Agronomy and Crop Science **5,** 1010–1105.
http://scialert.net/abstract/?doi=ja.2006.101105

Rademacher W. 1994. Gibberellin formation in microorganisms. Plant Growth Regulation **303,** 1514.

Rahmani HR. 2010. Bio-fertilizers and their roles in sustainable agriculture and healthy products. The 1st Iranian Fertilizer Challenges Congress. Half a Century of Fertilizer Consumption. 54-67 P.

Ramezani H. 2009.The effect of biological and chemical phosphorus fertilizers on yield and yield components of medical fennel.M. Sc. Thesis, Department of Agronomy, Shahed University.

Saeidnezhad AM, Rezvani Moghadam P. 2009. The effect of biological and chemical fertilizer on morphological properties, yield, and yield components of cumin. Journal of Horticultural Science **24(1),** 14-38.

Saleh Rastin N. 2001. Biological fertilizers and their role in sustainable agriculture. Collection of Researches on the Necessity of Industrial Production of Bio-fertilizers **34,** 1-54.

Shalaby AS, Razin AM. 1992. Effect of Plant Spacing on the Productivity of Roselle (*Hibiscus sabdariffa* L.) Grown in Newly Reclaimed Land. Journal of Agronomy and Crop Science**168,** 243-248.

Sinclair TR. 1998. Historical changes in harvest index and crop nitrogen accumulation. Crop Science. **38(3),** 638-643.

Sundara B, Natarajan V, Hari K. 2002. Influence of phosphorus solubilizing bacteria on the changes in soil available phosphorus and sugar cane and sugar yields. Field Crop Research **77,** 43-49.

Tapia-Hernandez A, Mascarua-Esparza MA, Caballero-Mellado J. 1990. Production of bacteriocins and siderophore-like activity by Azospirillumbrasilense. Microbios **64,** 73-83.

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

Vande Broek A. 1999. Auxins upregulate expression of the indol-3-pyruvate decarboxylase gene in Azospirillum brasilense. Journal of Bacteriology **181,** 1338-1342.

Youssef AA, Edris AE, Gomaa AM. 2004. A comparative study between some plant growth regulators and certain growth hormones producing microorganisms on growth and essential oil composition of *Salvia officinalis* L. Plant Annals of Agriculture Science **49,** 299-311.