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ORIGINAL ARTICLE

Effects of Biological and Chemical Fertilizers Nitrogen on Yield Quality and Quantity in Cumin (*Cuminum Cyminum* L.)

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KEYWORDS

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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 (Zero, 25 and 50 kg/ha^{-1}), biological nitrogen (*Azotobacter*) with trade name Nitroxin at 2 levels inoculated and non-inoculated in 2011. The results of analysis of variance showed that the effects of biological fertilizers (*Azotobacter*) Nitroxin of chemical (urea 46%) nitrogen in different treatments on plant height, umbel number per plant, grain number per umbel, biological yield, grain yield, harvest index (HI) and essential oil yield were significant at $P \leq 0.01$. The results showed that the greatest plant highest (28.18 cm), biological yield (201.187 g.m^2), grain yield (75.600 g.m^2) and essential oil yield (2.115 g.m^2) were obtained by a treatment of Nitroxin + chemical nitrogen (25 kg/ha^{-1}). In general, the results of the present study revealed that the application of biological fertilizers plays a remarkable role in improving yield quality and quantity in Cumin and can be viewed as a suitable replacement for chemical fertilizers.

INTRODUCTION

Medicinal plants are used to cure many ailments that are either non-curable or seldomly cured

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through modern systems of medicine. Approximately 80% of the world population depends on medicinal plants for their health and healing [3]. 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 [6]. 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 [15, 22]. 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 [22], antifungal, anti-carcinogenic [13], anti-diabetic, anti-thrombotic [12], and antioxidant properties [12, 33]. 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 [9]. There are some supporting studies that nitrogen fertilization affects yield, content, and composition of essential oils of medicinal plants [4]. However, nitrogen application presents conflicting results in regards to growth, essential oil yield and contents of medicinal plants Economakis and colleagues [10] showed that nitrogen fertilization had no effect on essential oil content of *Origanum dictamnus*. Biological fertilizers (*Azotobacter*) absorbed and increased the concentration of essential elements such as nitrogen, phosphorus, potassium, zinc, magnesium, iron, and protein in crops [14]. 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 [26]. Despite the significant positive effects of *Azotobacter* on plants, the exact function in the development of plant growth is still unknown. Pereira and colleagues [24] 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} [20]. Nitrogen improved the performance of more than 30% of Geranium (Pelargonium) and other medicinal plants [25]. 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% [7]. 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* [14]. Research showed that the amount of nitrogen up to 120kg/ha^{-1} produced more *thymol* yield in *thyme* oil but there was no significant effect on the amount of seed oil [2]. Nitrogen increased *thymus vulgaris* oil yield and percent *thymol* and the best treatment was 100 kg N/ha^{-1} [27]. 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 [2].

MATERIALS AND METHODES

The experiment was carried out in 2011 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 shown in Table

1. The field was prepared in autumn and in March, the crop was planted. 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 (46% urea nitrogen) zero, 25 and 50 kg/ha 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 (Nitroxin) 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.

Table 1. physical and chemical properties of the experimental soil

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

RESULTS AND DISCUSSION

Plant height

The results of the analysis variance showed that the plant height was significantly affected by all 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 Nitroxin + chemical nitrogen (25kg/ha^{-1}) and control, respectively (Figure 1). According to the present analysis, Nitroxin increased plant height by enhancing the nitrogen content and the rate of photosynthesis [11]. The current results were derived from the cultural practices and plant protection measures were followed uniformly for all the plots during the entire period of experimentation. Dried seeds (50 gr) of each plot were separated and powdered. The powder subjected to hydro distillation (400 ml distilled water), using a Clevenger-type apparatus for 2.5 hours and its essential oil was separated. Collected essential oil value was expressed regarding seed weight as essential oil yield. 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. In this experiment plant height, umbel number per plant, grain number per plant, grain number per umbel, weight of 1000 grains, biological yield, grain yield, harvest index (HI), essential oil percentage and essential oil yield were studied. Fifteen plants were randomly selected from each plot and the observations were recorded. Improvement of nitrogen fixing bacteria activities in soil, which correlates to the previous studies carried out on the fennel, cerely, black cumin and hyssop [16, 21, 29 and 32].

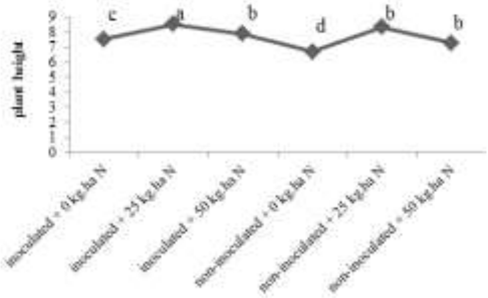

Figure 1. Effects of biological and chemical fertilizers nitrogen on plant height in Cumin

Umbel number per plant

The results indicated that umbel number per plant was significantly affected by all treatments (P≤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 Nitroxin + chemical nitrogen (25 kg/ha^{-1}) and control, respectively (Figure 2).

Nitroxin 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 and colleagues [32] on *Foeniculum vulgare*, Migahed and colleagues [21] on *Apium graveolens*, Shaalan [29] on *Nigella sativa* and Darzi et al. [8] on *Coriandrum sativum*.

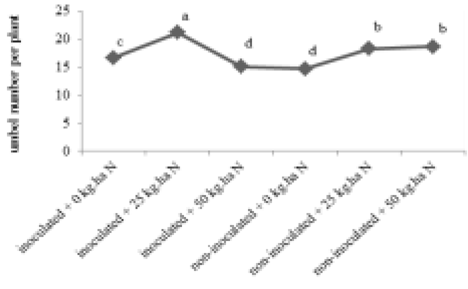

Figure 2. Effects of biological and chemical fertilizers nitrogen on umbel number per plant in Cumin

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 (Figure 3) showed that the highest grain number per plant (3.1) was determined by Nitroxin + chemical nitrogen (25kg/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* [1, 29].

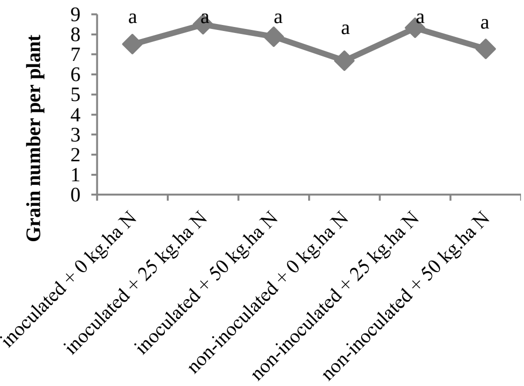

Figure 3. Effects of biological and chemical fertilizers nitrogen on grain number per plant in Cumin

Grain number per umbel

Analysis of variance (ANOVA) of data showed that the effect of by all 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 Nitroxin + chemical nitrogen (25kg/ha^{-1}) and control, respectively (Figure 4). Effect of Nitroxin on the grain number per umbel of plant was due to increased nitrogen uptake and growth rate improvement [35]. The results of this experiment are similar to the reports of Youssef and colleagues [36] on *Salvia officinalis* and Valadabadi and Farahani [34] on *Nigella sativa*.

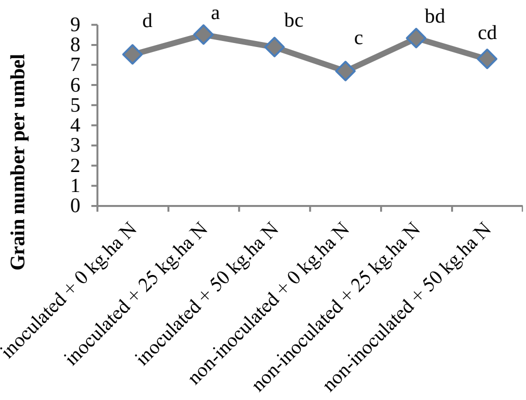

Figure 4. Effects of biological and chemical fertilizers nitrogen on grain number per umbel in Cumin

Weight of 1000 grains

The results showed that all treatments did not have a significant effect on weight of 1000 grains (Table 2). Mean comparison table showed that the highest (5.9 g) and lowest (5.3g) weight of 1000 grains were obtained by a treatment of Nitroxin + chemical nitrogen (25kg/ha^{-1}) and control, respectively (Figure 5). Nitroxin increased the weight of 1000 seeds by the biomass production improvement [28]. The result is similar to the report of Darzi and colleagues [8] on fennel.

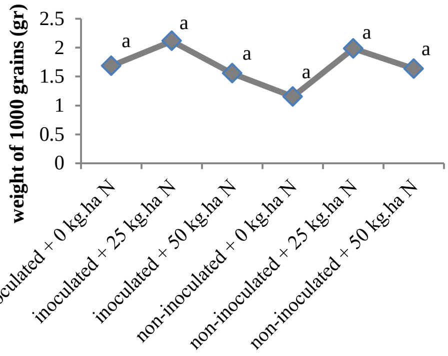

Figure 5. Effects of biological and chemical fertilizers nitrogen on weight of 1000 grains (gr) in Cumin

Biological yield

The results of the analysis variance showed that the biological yield was significantly affected by all treatments (P≤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 Nitroxin + chemical nitrogen (25 kg/ha^{-1}) and control, respectively (Figure 6). Effect of Nitroxin on the biological yield of plant was due to increased nitrogen uptake and the growth rate improvement [35]. The result of this study is similar to the reports of Youssef and colleagues [36] on *Salvia officinalis*, Kumar and colleagues [18] on *Artemisia pallens* and Valadabadi and Farahani [34] on *Nigella sativa*.

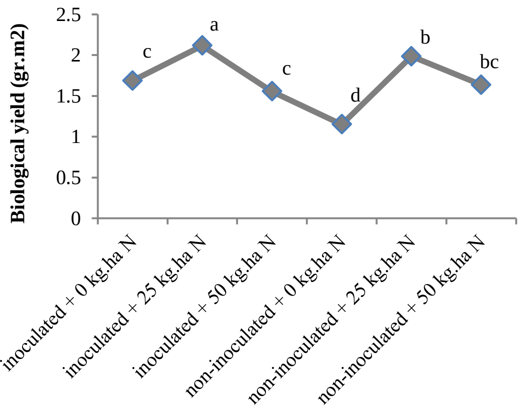

Figure 6. Effects of biological and chemical fertilizers nitrogen on biological yield (gr.m2) in Cumin

Grain yield

The results presented in Table 2 indicate that different levels of treatments had significant effects on the grain yield (P≤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 Nitroxin + chemical nitrogen (25 kg/ha^{-1}) and control, respectively (Figure 7). Increased seed yield in Nitroxin 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 results correlate to the investigation of Kumar and colleagues [18] and Darzi and colleagues [8] on *Coriandrum sativum*, Migahed and colleagues [21] on *Apium graveolens*, Tehlan and colleagues [32], Shaalan [29] and Valadabadi and Farahani [34] on *Nigella sativa.*

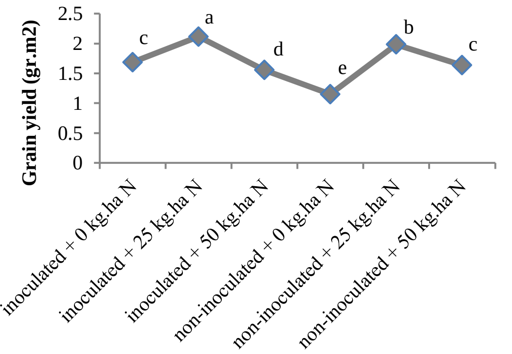

Figure 7. Effects of biological and chemical fertilizers nitrogen on grain yield (gr.m2) in Cumin

Harvest index (HI)

The results of the analysis variance showed that the harvest index was significantly affected by all 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 Nitroxin + chemical nitrogen (25kg/ha^{-1}) and control, respectively (Figure 8). 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 in 2008 [17]. 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 [31].

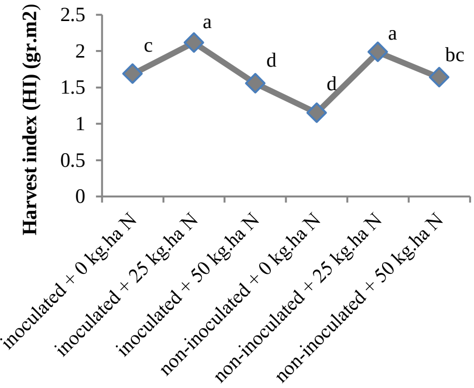

Figure 8. Effects of biological and chemical fertilizers nitrogen on harvest index (HI) (gr.m2) in Cumin

Essential oil percentage

The results showed that all 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 Nitroxin + chemical nitrogen (25 kg/ha^{-1}) and control, respectively (Figure 9). 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. There are studies that support the notion that nitrogen fertilization affects content and composition of secondary metabolites in medicinal plants [4, 23].

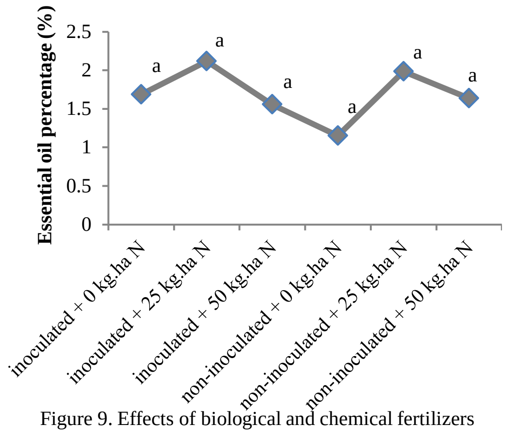

Figure 9. Effects of biological and chemical fertilizers nitrogen on essential oil percentage (%) in Cumin

Essential oil yield

The results of the analysis variance showed that the essential oil yield was significantly affected by all treatments ($P \leq 0.01$) 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 Nitroxin + chemical nitrogen (25 kg/ha^{-1}) and control, respectively (Figure 10). 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 [19]. The results of this study confirm the results of Azizi [5] on the effect of nitrogen on the essence yield in anis plant. Shalaby and Razin [30] reported that application of 105 kg/ha^{-1} of nitrogen increased essence and *thymul* in *Thymus* plant.

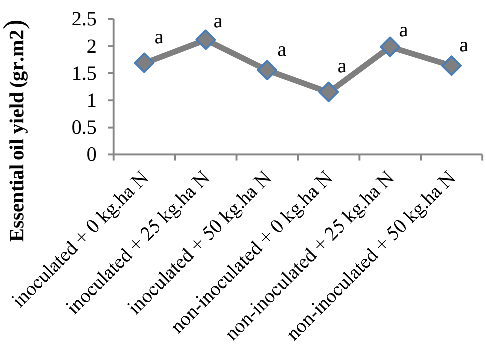

Figure 10. Effects of biological and chemical fertilizers nitrogen on essential oil yield (gr.m2) in Cumin

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 quality and quantity features in cumin. Maximum of plant height, umbel number per plant, grain number per umbel, biological yield, grain yield, harvest index (HI) and essential oil yield was obtained in the treatment of Nitroxin + 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

Table 2. Analysis of variance for effects of biological and chemical fertilizers nitrogen on yield quality and quantity in Cumin

Resource changes	df	umbel number per plant	grain number per umbel	plant height	grain number per plant	weight of 1000 grains	biological yield	grain yield	harvest index (HI)	essential oil percentage	essential oil yield
Repetition	2	18.141 ns	1.562 ns	15.870 ns	1.383 ns	13.802 ns	608.183 ns	121.295 ns	14.500 ns	4.020 ns	1.819 ns
Nitroxin	1	197.884 **	5.210 **	1.033 **	0.683 ns	0.440 ns	5208.333 **	2715.021 **	365.486 **	0.130 ns	1.552 **
Nitrogen	2	63.479 **	16.027 **	0.593 **	0.138 ns	0.093 ns	9238.695 **	4782.342 **	472.421 **	0.053 ns``	3.985 **
Nitroxin× Nitrogen	2	106.224 **	1.069 **	4.481 **	0.648 ns	1.697 ns	1265.298 **	375.964 **	76.136 **	0.146 ns	0.491 **
Error	10	2.433	0.367	2.459	0.400	0.553	61.914	9.049	2.789	0.130	0.055
CV (%)	-	8.93	8.00	8.76	21.07	13.11	4.45	5.07	5.10	11.161	14.07

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

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