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Influence of biological and chemical nitrogen fertilizers on grain yield and yield components of Fennel (*Foeniculum vulgare* Mill.)

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Abstract

In order to study the effect of biological and chemical fertilizers nitrogen on grain yield and yield components of Fennel (*Foeniculum vulgare* Mill.), an experiment was conducted as factorial experiment in the base of randomized complete blocks design with six treatments and three replications at research farm of Khorramabad in Lorestan of Iran in 2013. The factors were chemical nitrogen (46% urea nitrogen) at three levels (Zero, 25 and 50 kg.ha-1), biological nitrogen (Azotobacter) with trade name Nitroxin at two levels inoculated and non-inoculated. 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 and grain yield were significant at P≤0.01. The means showed that the maximum plant highest (107 cm) and grain yield (1017 kg.ha^{-1}) were obtained by a treatment of Nitroxin + chemical nitrogen (25 kg.ha^{-1}). In general, results of the present study revealed that application of biological fertilizers plays a remarkable role in improving grain yield and yield components of Fennel and they can be viewed as a suitable replacement for chemical fertilizers.

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Introduction

Medicinal and aromatic plants have the economic importance because of the continuous and increasing demand for their products by local and international markets (Khalid, 2006). Fennel (*Foeniculum vulgar* Mill.) is one of the most important medicinal plants. It is a perennial and hardy herb that grows in many parts of the world, especially on dry soil near the coasts. The bulb, foliage and seeds are used in many of the culinary traditions of the world. Fennel stimulates appetite and aids digestion. It is also used for kidney stones, menopausal problems, nausea and obesity (Zahid *et al.*, 2009). Wild and cultivated fennel has different size, odor, taste, quality and yield potential. Therefore, it is important to select superior accession for cultivation. 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 N fertilization affects yield, content, and composition of essential oils of medicinal plants (Ashraf *et al.*, 2006). However, nitrogen application presents conflicting results in regard to growth, essential oil yield and contents of medicinal plants. There are some supporting studies that N fertilization affects yield, content, and composition of essential oils of medicinal plants (Ashraf *et al.*, 2006). However, nitrogen application presents conflicting results in regard to growth, essential oil yield and contents of medicinal plants. Economakis *et al.* (1999) showed that N fertilization had no effect on essential oil content of *Origanum dictamnus*. Biological fertilizers (*Azotobacter*) absorb and increasing the concentration of essential elements such as nitrogen, phosphorus, potassium, zinc, magnesium, iron and protein in crops (Habibi, 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 percent. 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 (Mandel, 2003). Nitrogen improved the performance of more than 30 percent 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 percent (Bullock, 1999). Also 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, 2004). Research showed that the amount of nitrogen up to 120 $kg.ha^{-1}$ produced more *thymol* yield in *thyme* oil, but had no significant effect on the amount of seed oil (Akbari Niea, 2004). Nitrogen increased *thymus vulgaris* oil yield and percent *thymol* and the best treatment was 100 kg N/ha (Rezaei Nejad, 2000). Research showed that by increasing nitrogen application from 105 to 120 kg.ha-1 the essence yield and *thymol* increased significantly, but had no significant effect on the amount of seed oil (Akbari Niea, 2004). Aims of the study evaluation of biological and chemical fertilizers nitrogen on grain yield and yield components of Fennel.

Materials and methods

Experiment carried out

The experiment was carried out in 2013 at the research farm Khorramabad, Lorestan Iran, located in the longitude 48º and 21' and the latitude 320 and 30' with a height of 1117 m above sea level, with annual precipitation of 524 mm and average annual temperature of 17º C.

The physical and chemical properties

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.

Design experiment

The experiment was a 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^{-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 50 cm between the rows and a distance of 20 cm between plants in the rows. There was a space of one meter between the plots and two meters between replications. The Fennel seeds were planted distance were two cm 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

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. Fennel 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.

Measurement of characteristics

In order to measurement of characteristics of effective on yield components and substance effective, after removing the marginal effects of each plot, 10 plants from each plot were harvested randomly. All necessary cultural practices and plant protection measures were followed uniformly for all the plots during the entire period of experimentation.

Data 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. In this experiment plant height, umbel number per plant, grain number per umbel, weight of 1000 grains and grain yield were studied. Fifteen plants were randomly selected from each plot and the observations were recorded.

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 (107 cm) and lowest (83 cm) plant height were obtained by a treatment of Nitroxin + chemical nitrogen (25 kg.ha^{-1}) and control, respectively (Table 3). According to the present analysis, Nitroxin have increased plant height by enhancing the nitrogen content and the rate of photosynthesis (Fatma *et al.*, 2006). The present result were derived from the improvement of nitrogen fixing bacteria activities in soil, which is in agreement with the previous studies carried out on the fennel, cerely, black cumin and hyssop (Tehlan *et al.*, 2004; Migahed *et al.*, 2004; Shaalan, 2005; Koocheki *et al.*, 2009).

Table 1. several physical and chemical properties of the experimental soil.

Ec mmos/cm	pH	Cu ppm	Zn ppm	Mn ppm	Fe ppm	N ppm	K ppm	P ppm	O.C (%)	Deep (cm)
0.61	7.7	0.68	0.8	6.6	7.6	80	230	8	0.79	0-30

Umbel number per plant

The present results have indicated that umbel number per plant was significantly affected by all treatments ($P \leq 0.01$) in this experiment (Table 2). Mean comparison table showed that the highest (75) and lowest (48) umbel number per plant were obtained by a treatment of Nitroxin + chemical nitrogen (25 kg.ha^{-1}) and control, respectively (Table

3). 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 Tehlan *et al.* (2004) on *Foeniculum vulgare*, Migahed *et al.* (2004) on *Apium graveolens*, Shaalan (2005) on *Nigella sativa* and Darzi *et al.* (2012) on *Coriandrum sativum*.

Table 2. Analysis of variance for Influence of biological and chemical fertilizers nitrogen on grain yield and yield components of Fennel (*Foeniculum vulgare* Mill).

Resource changes	df	umbel number per plant	grain number per umbel	plant height	weight of 1000 grains	grain yield
Repetition	2	85.500 ns	86.722 ns	91.167 ns	0.368 ns	571.500 ns
Nitroxin	1	684.500**	364.500**	220.500 **	0.168 ns	15488.000**
Nitrogen	2	514.500**	648.722**	303.500**	0.478 ns	6159.500**
Nitroxin × Nitrogen	2	75.500**	340.167**	73.500 **	0.041 ns	2187.500**
Error	10	1.700	33.589	55.967	0.206	3182.900
CV (%)	-	2.16	7.91	8.06	10.16	6.03

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

Grain number per umbel

Analysis of variance (ANOVA) of data showed that the effect of by all treatments were significant at 1% probability level, respectively (Table 2). Mean comparison table showed that the highest (88) and lowest (57) grain number per umbel were obtained by a treatment of Nitroxin + chemical nitrogen (25 kg.ha^{-1}) and control, respectively (Table 3). Effect of Nitroxin on the grain number per umbel of plant was due to increased nitrogen uptake and the growth rate improvement (Vande Broek, 1999). The results of present work are in agreement with the reports of Youssef *et al.* (2004) on *Salvia officinalis* and Valadabadi and Farahani (2011) on *Nigella sativa*.

Table 3. Mean comparison of the Influence of biological and chemical fertilizers nitrogen on grain yield and yield components of Fennel (*Foeniculum vulgare* Mill).

Treatments	umbel number per plant	grain number per umbel	plant height (cm)	weight of 1000 (gr)	grain yield (kg. ha-1)
N1+	54 d	82 a	93 ab	4.51 a	942 ab
N2+	75 a	88 a	107 a	4.81 a	1017 a
N3+	71 b	63 b	89 b	4.38 a	936 ab
N1-	48 f	57 b	83 b	4.15 a	875 b
N2-	64 c	82 a	95 ab	4.78 a	925 ab
N3-	53 e	67 b	90 b	4.19 a	919 ab

*In each column, means with the similar letters are not significantly different at 5% level of probability using Duncan's test. +: Seeds inoculation to biofertilizer nitroxin, -: non-inoculated, Control (without fertilizer), N2: 25 kg/ha^{-1} chemical nitrogen fertilizer, N3: 50 kg/ha^{-1} chemical nitrogen fertilizer.

Weight of 1000 grains

The present results showed that by all treatments had not significant effect on weight of 1000 grains (Table 2). Mean comparison table showed that the highest (4.81 gr) and lowest (4.15) weight of 1000 grains were obtained by a treatment of Nitroxin + chemical

nitrogen (25 kg.ha-1) and control, respectively (Table 3). Nitroxin have increased weight of 1000 seeds by the biomass production improvement (Roy and Singh, 2006). The present result is in agreement with the report of Darzi *et al.* (2007) on fennel.

Grain yield

The results presented in Table 2 have revealed that different levels of treatments had significant effects on the grain yield (P≤0.01). Mean comparison table showed that the maximum (1017 kg.ha^{-1}) and minimum (40.867 kg.ha^{-1}) grain yield were obtained by a treatment of Nitroxin + chemical nitrogen (25 kg.ha^{-1}) and control, respectively (Table 3). Increased seed yield in Nitroxin treatments can be owing 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 are in agreement with the investigation of Kumar *et al.* (2002) and Darzi *et al.* (2012) 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. Application of biological fertilizer significantly improved grain yield and yield components in Fennel. Maximum of plant height, umbel number per plant, grain number per umbel and grain yield was obtained in treatment of Nitroxin + chemical nitrogen (25 kg/ha^{-1}). Totally, the obtained results revealed that using biological fertilizer combined with chemical fertilizer significantly improved the quantity and quality characters compared to control.

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