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Original article

Effect of biological phosphate and chemical phosphorus fertilizer on yield and yield components of Ajowan (*Carum Copticum*)

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ABSTRACT

In order to study the effect of biological phosphate and chemical phosphorus fertilizer on yield quality and quantity of Ajowan (Carum copticum) medicinal plant, an experiment was conducted as factorial experiment in the base of randomized complete blocks design and three replications at research farm of Khorramabad in Lorestan of Iran in 2013. Treatments included biological phosphate (Pseudomonas putida) at two levels inoculated and non-inoculated and chemical phosphorus (P_2O_5) at three levels (Zero, 50 and 100 $kg.ha^{-1}$). Results showed that effect of treatments on plant height, umbel number per plant, grain number per umbel and grain yield were statically meaningful, however, there were no significant differences between treatments in about weight of 1000 grains. The means showed that the greatest plant highest (70 cm) and grain yield (475 $kg.ha^{-1}$) were obtained by a treatment of biological phosphate + chemical phosphorus (50 $kg.ha^{-1}$ P_2O_5). Results indicate that applying the combined biological phosphate and chemical phosphorus fertilizer can be practical and helpful method to increase Ajowan yield, yield components and reduce the environmental pollution.

1. Introduction

Plants as a first part of food cycle have essential role in human life. The total dependency on plants has forced human to use science and the new methods to earn more information about plants (Krishnamoorthy et al., 2000). During the history of medical cure the use of medical plants has been consistent. The potential of producing medical plants has been great in Iran for a long time. The side effects of chemical medicines make medical plants more popular among the other ways of treatment, and so this herbs worth a lot (Sharifiashoriabadi et al., 2002). Ajowan (Carum copticum) belonging to the Apiaceae family is a grassy, annual plant with a white flower and small, brownish seeds which commonly growsin Iran, India, Egypt and Europe. The seeds have been used for their flavour and spice in food industry. Also, the Ajowan seeds have essential oil as an active substance, which is used in pharmaceutical industry as a diuretic, anti vomiting, analgesic, antiasthma, antispasmodic and a carminative (Nagalakshm and Shankaracharya, 2000; Khajeh et al., 2004). Since, application of chemical fertilizer increase the soil and water pollution and accumulation of some heavy metals such as cadmium, they can threat the human health. Moreover, the long-term use of chemical fertilizers tends to the soil structure degradation (Singh et al., 2008). Nowadays, attention to biological fertilizer has been increased due to price of chemical fertilizers and attention to sustainable agricultural systems (Ehteshami et al., 2007). Biological fertilizers containing beneficial bacteria and fungi improve soil chemical and biological characteristics, phosphorus solutions and agricultural production (El-Habbasha et al., 2007; Yosefi et al., 2011). Some bacteria provide plants with growth promoting substances and play major role in phosphorus solubilizing (Abou-Aly et al., 2006). Biological fertilizers have improved quantity and quality features of some plants (Ratti et al., 2001). Biological fertilizers comprised of nitrogen fixers, phosphorus dissolvers and available potassium (Ezz et al., 2011). An advantageous of phosphorus solubilizing microorganisms is related to their propagation rate that can relatively remove the plant requirements to phosphorus at the root region (Sharma, 2002). Belimov et al. (1995) demonstrated that, inoculation of soil with bacterial mixtures caused a more balance nutrition for plants and improvement in root uptake of nitrogen and phosphorus in a main mechanism of interaction between phosphorus solubilizing and bacteria nitrogen fixing. Ratti et al. (2001) investigated effect of some varieties of phosphorus solubilizing bacteria on the yield of Lemon Grass (Cymbopogon) and concluded that the plant height and biomass increased compared to the control condition. Hazarika et al. (2000) reported that the use of phosphorus solubilizing bacteria significantly increased the nursery establishment and growth of tea plant. In another research, Kapoor et al. (2004) showed that fennel root symbiosis with pseudomonas significantly increased the flowering, 1000 seeds weight, dry matter and seed yield. Kapoor et al. (2007) reported that the inoculation of root with a kind of phosphorus solubilizing bacteria enhanced the shoot dry matter. The study showed significant improvement in seed yield of medical plant as Phyllanthus amarus under using of solving phosphorus bacteria in compare to the control (Annamalai et al., 2004). Inoculation the medical plants by pseudomonas causes to increase the root growth and plant growth ability in soil with fewer amounts of phosphorous (Mubassara et al., 2008). Therefore, the aim of this study was to investigate the effect of different treatments methods of biological phosphate and chemical phosphorus fertilizer on yield and yield components of Ajowan (Carum copticum).

2. Materials and methods

The experiment was carried out in 2013 at the research farm Khorramabad in 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 17oC. 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. The experiment was a factorial with two factors arranged in a randomized complete block design with three replications. The first factor was biological phosphate (bacterial strain Pseudomonas putida) at two levels; inoculated (+) and non-inoculated (-) and second factor was three levels of chemical phosphorus fertilizer (P2O5) 0, 50 and 100 kg.ha-1. The area of the each experimental plot was 2*3 meter, 50cm distance between the rows and 20 cm between the plants. The Ajowan 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. Three-quarters of fertilizer was applied at planting seeds and the rest was applied to plant at shooting. Ajowan seeds were directly sown by hand. There was no incidence of pest or disease on Ajowan during the experiment. Basin irrigation until harvest was done depending on weather conditions and weeds were controlled.

In order to measure the characteristics of effect on yield components and substance, 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 was done by using software SPSS. 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 umbel number per plant, grain number per umbel, weight of 1000 grains, biological yield and grain yield were studied.

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

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

3. Results and discussion

3.1. 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). This suggests the increase in plant height under influence of phosphorus fertilizers treatments, as the highest plant height (70 cm) was obtained by application of biological phosphate + chemical phosphorus (50 kg.ha-1 P_2O_5), and the lowest (52 cm) plant height was obtained in control treatment (non fertilizer application) (Figure. 1). Biological phosphate fertilizer increased root uptake through root development. Furthermore, application of biological fertilizer increased plant height by increasing plant growth regulator hormones production (such as IAA and GA) (Senthil-Kumar et al., 2009). The obtained data are in general agreement with those reported by Shaalan (2005), Singh et al. (2008) and Ezz et al. (2011). Showed that the using of phosphorus fertilization and/or effective microorganisms as a biological fertilizer increased all studied vegetative growth characters including plant height. Singh et al. (2008) revealed the positive effect of biological fertilizer on the plant height of Calendula officinalis L. Similar observations have been reported by Chandrikapure et al. (1999) in marigold.

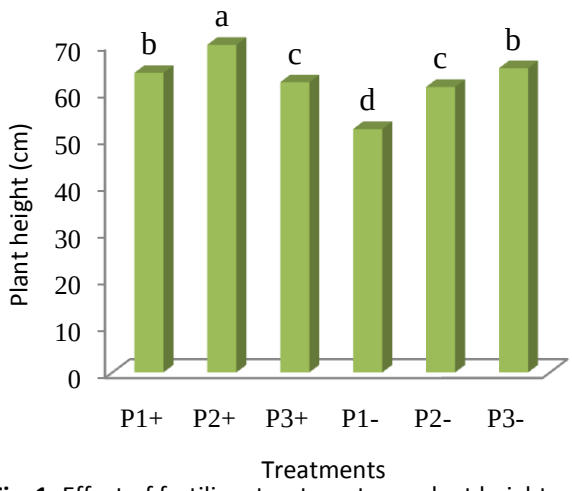

Fig. 1. Effect of fertilizer treatments on plant height.

3.2. Umbel number per plant

Table 2 shows that the umbel number per plant was significantly ($P \leq 0.01$) affected by biological phosphate fertilizer and chemical phosphorus. The mean comparison of data in different treatments showed that maximum

umbel number per plant (262) was determined by application of biological phosphate + chemical phosphorus (50 kg.ha-1 P2O5). Minimum number of umbel number per plant (187) was obtained in control plants (non fertilizer application) (Figure. 2). Our findings are in agreement with those reported by some other researchers. Singh et al. (2008) showed that maximum umbel number per plant in Calendula officinalis L. was obtained under application of biological fertilizer along with 75% of chemical fertilizer. Studies of Abou El-Yazeid and Abou-Aly (2011) demonstrated that the umbel number per plant had significantly higher value under application of phosphorus solubilizing microorganisms combined with rock phosphorus treatments compared to control. This could be attributed to the highest values of available phosphorus compared to other treatments.

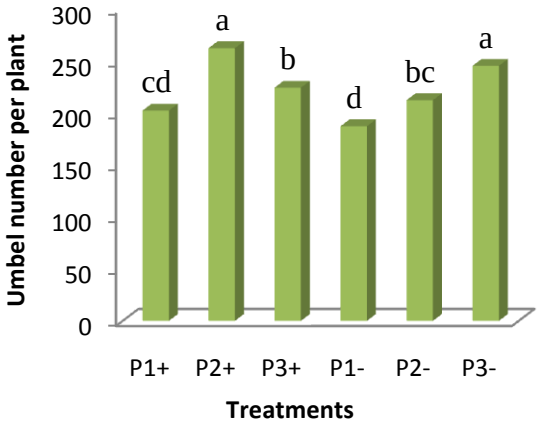

Fig. 2. Effect of fertilizer treatments on umbel number per plant.

3.3. Grain number per umbel

Results showed that grain number per umbel was significantly (P≤0.01) affected by biological phosphate fertilizer and chemical phosphorus (Table 2). The mean comparison of data in different treatments showed that the highest grain number per umbel (31) was achieved by application of biological phosphate + chemical phosphorus (50 kg.ha-1 P2O5). The lowest grain number per umbel (22) was obtained in control treatment (non fertilizer application) (Figure. 3). Biological phosphate fertilizer has significantly influenced the umbel number per plant. On the other hand, biological phosphate fertilizer application through the improvement of biological activities of soil and mineral element absorption caused more biomass production and grain number per umbel. Investigations of Sanchez Govin et al. (2005) on Calendula officinalis and Matricaria recutata, Mahfuz and Sharafeldin (2007) in Foeniculum vulgare Mill, Abou El- Yazeid et al. (2007) in Cucurbita, and Dehghani Meshkani et al. (2011) in Matricaria recutita confirm our findings. Study of Ezz et al. (2011) on banana (Musa spp.) showed that the using of phosphorus fertilization and/or effective microorganisms as a biological fertilizer increased all studied vegetative growth characters.

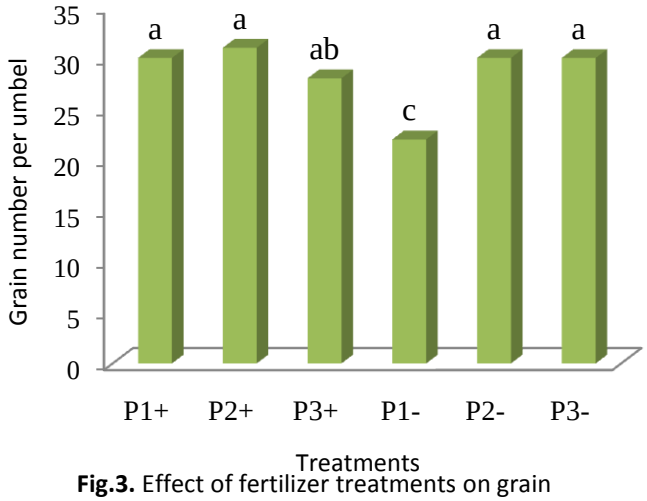

Fig.3. Effect of fertilizer treatments on grain number per umbel.

3.4. Weight of 1000 grains

The present results showed that by all treatments had not significant effect on weight of 1000 grains (Table 2). Phosphorus has increased weight of 1000 grains by the biomass production improvement (Ezz et al. 2011). The present result is in agreement with the report of Dehghani Meshkani et al. (2011) on Matricaria recutita L.

3.5. 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 (475 kg.ha-1) and minimum (377 kg.ha-1) grain yield were obtained by a treatment of biological phosphate + chemical phosphorus (50 kg.ha-1 P2O5) and control (non fertilizer application), respectively (Figure. 4). Increase of grain yield under the influence of phosphorus fertilizers, can be attributed to the ability of phosphorus solution bacteria in fertilizer in increasing phosphorus liberalization of insoluble phosphorus sources. In another study Rokhzadi et al., (2004) reported that grain yield of chickpea increased by utilization of biological fertilizer.

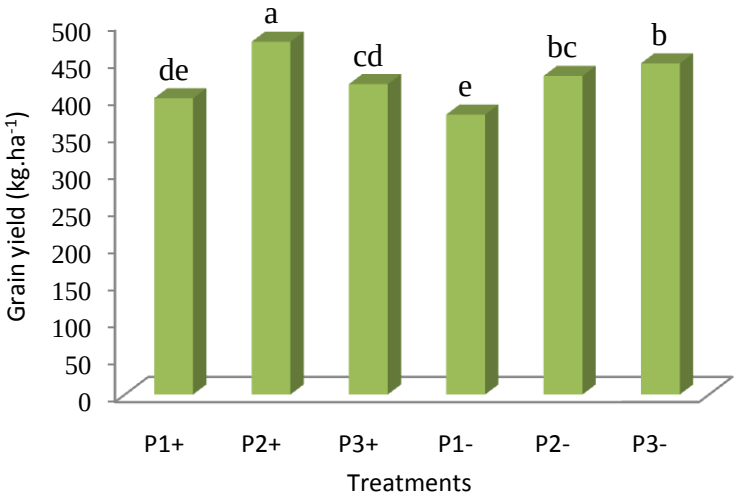

Fig. 4. Effect of fertilizer treatments on grain yield.

Table 2
Analysis of variance for biological phosphate and chemical phosphorus fertilizer on yield and yield components of Ajowan (*Carum copticum*).

Resource changes	df	Umbel number per plant	Grain number per umbel	Weight of 1000 grains	Grain yield	Biological yield
Repetition	2	1660.389 ns	52.603 ns	0.002 ns	4526.222 ns	8480.056 ns
Biological phosphate (A)	1	982.722 *	17.860 **	0.001 ns	747.556 ns	177012.500 **
Chemical phosphorus (B)	2	3427.556 **	28.981 **	0.002 ns	6504.222 **	2299.389 **
(A) × (B)	2	1908.222 **	42.892 **	0.001 ns	2146.889 **	74388.167 **
Error	10	100.789	48.310	0.001	172.089	6421.122
CV (%)	-	4.52	24.09	10.44	3.09	5.04

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

4. Conclusion

Biological fertilize are widely applied in crop production and they are proper substitutions for chemical fertilizers. Application of biological fertilizes significantly improved yield and yield components in Ajowan. Maximum of umbel number per plant, grain number per umbel, biological yield and grain yield was obtained in treatment of biological phosphate + chemical phosphorus (50 kg.ha-1 P2O5). Totally, the obtained results revealed that using biological fertilizes combined with chemical fertilizer significantly improved the yield and yield components compared to control.

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