



RESEARCH PAPER

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Bio-nutrient seed priming may improve growth and essential oil yield of cumin (*Cuminum cyminum L.*)

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Abstract

Cumin (*Cuminum cyminum L.*) is one of the most important medicinal plants in Iran. In order to determine the effects of seed bio-nutrient priming on yield of cumin a field experiment was conducted in Tabriz, Iran, during 2010. The cumin seeds local variety, *Mashhad*, were soaked in the solutions of micro-elemental chemicals as iron, zinc, manganese, boron and molybdenum; and after that the dried seeds were bio-primed with *Azospirillum* strains (*lipoferum*, *brasilense*, *irakense*, *strain of* and *strain 21*). Results revealed that the highest umbel number per plant obtained from those seeds treated with micro-elements solution and inoculated with *Azospirillum strain 21*. The lowest 1000 seeds weight (2.3 g) was produced from those seeds with not only bio-fertilized but also nutrient primed treatment that had 65% reduction in 1000 seeds weight. In treatments with greater yield (*A. strain of* or *A. strain 21* × nutrient primed seeds), the yield improved 425 and 455 kg ha⁻¹, respectively, as compared to the control. Essential oil yield on cumin seeds was in range of 17.2 L ha⁻¹ in treatment of seed coating with micro-nutrients × *A. strain of* and *A. strain 21* up to 2.56 L ha⁻¹ in control. The stepwise regression analysis verified that the umbel number per plant and TSW had a marked increasing effect on the seed yield of cumin. It was concluded from the study that cumin seed and its essential oil yield could be improve by simultaneously seed priming with *Azospirillum strain of* or *strain 21* and nutrient priming with iron, zinc, manganese, boron and molybdenum in semi-arid and cold regions.

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Introduction

Cumin (*Cuminum cyminum* L.) is one of the medicinal plants of the Apiaceae family; due to its estrogenic activities and usage as a carminative and antimicrobial; it has also been used to increase the production of milk in humans and animals (Mahfouz, S.A. and Sharaf-Eldin, 2007). It's seed volatile oil has a traditional reputation as an aid to weight loss and longevity (Fathy *et al.*, 2002). In Iran, cumin is grown in semi-arid regions as a cold season crop (Omidbeigi, 2007). It is considered to be one of the most important medicinal plants, after saffron (*Crocus sativus* L.), in Iran.

One of the major crop productivity constraints in the world is the unavailability of crop nutrients in both adequate amount and proper form to crop plants (Hussain *et al.* 2006). Nitrogen is required in large quantities for plants to grow, and is mainly provided in the form of synthetic chemical fertilizers. Such products pose a health hazard and microbial population problem in soil, besides making the production cost high (Badran and Safwat, 2002). Biofertilizers are able to fix atmospheric nitrogen in the available form for plants (Chen, 2006). There are number of microbial inoculants like *Azospirillum* and *Azotobacter* used as biofertilizers which have been given much attention as they are responsible to plant growth and yield of medicinal plants under field inoculation (Badran and Safwat, 2002).

The roles of both macro and micronutrients in crop nutrition are undisputable and thus they are quite important for achieving higher yields (Arif *et al.* 2006). However, they are limiting factors in most of the soils and thus must be supplemented through proper crop nutrients management (Hossain *et al.* 2006). Sivritepe and Dourado (1995) reported that priming is a physiological method that improves seed performance and provides faster and synchronized germination. In an experiment conducted by Kaymak *et al.* (2009) on radish (*Raphanus sativus* L.) germination rate was higher in seeds treated with PGPR than in the control.

Micronutrients are required in very small quantities (Abd El-Wahab 2008). There are mainly three methods of micronutrients application in crops: application to soil, foliar sprays and seed treatment (Johnson *et al.* 2005). Each method may affect plant growth differently. Using enriched seeds by micronutrient, seed priming, has been reported to be a better strategy in overcoming micronutrient deficiencies (Harris *et al.* 1999; Musakhandov 1984). There are evidences that sowing seeds enriched with micronutrients is also agronomically beneficial (Rerkasem *et al.* 1990; Welch 1986).

Multiple micronutrient deficiencies of Zn, Mn, Cu, B, Fe and Mo occur in the soils of Iran, and are becoming more prevalent as cropping intensity increases. As much as 49% of soils in Iran have Fe and B deficiencies, but only less than 16% of farmers use Fe and B fertilizers in their farms (Malakouti *et al.* 2009). It is, thus, decided to determine the effects of bio-nutrient priming cumin seeds on growth, yield and essential oil of cumin.

Materials and Methods

Field experiment was conducted at the Agricultural Research Station of Islamic Azad University of Tabriz, Iran, during growing season of 2010. Tabriz locater in the north-west of Iran, and the climate is semi-arid and cold and average annual precipitation is 256 mm. The soil was sandy-loam with EC of 0.74 ds m⁻¹ and pH of 7.1-7.7 ds m⁻¹. Total nitrogen content of the soil was 0.09%; phosphorous and potassium contents of 70 mg kg⁻¹ and 375 mg kg⁻¹; and Fe and B contents of 6 mg kg⁻¹ and 1 mg kg⁻¹. The experimental field had been in a potato-barley rotation cycle for the last two years. The experimental area was ploughed in the fall and manured with 8 t ha⁻¹. Field was cultivated, disked, and then platted in spring before sowing the seeds. Fertilizers used, in spring and before sowing, were 110, 50 and 15 kg ha⁻¹ of ammonium phosphate, potassium sulfate and urea, respectively, based on soil analysis. The size of plots was 3 by 3 m. Each plot consisted of seven cumin rows spaced 40 cm apart. Factorial experiment was arranged based on

randomized complete block design with three replications.

Primarily, the cumin seeds local variety, *mashhad*, were soaked in the required aqueous solutions of micro-elemental chemicals as iron, zinc, manganese, boron and molybdenum for 24 hours, as recommended by Water and Soil Institute of Iran; and after that the dried seeds were bio-primed with *Azospirillum* strains (*lipoferum*, *brasilense*, *irakense*, *strain of* and *strain 21*) included an-other treatment as control. The treated seeds were sown at four centimeter depth with a density of 100,000 plants ha⁻¹ on 20th April.

Also all plots were hand removed for other weed species in growing season. Plots were irrigated immediately after sowing to assure uniform emergence. No herbicide, neither before nor after sowing, was used to control weeds. At harvesting stages, the middle four green bean rows of each plot were hand harvested.

Statistical analysis

All data were analyzed using the MSTAT-C software. Treatment means were separated using Fischer's Protected LSD at P= 0.05 level. Regression analysis was performed to describe the relationship between bean yield and duration of redroot pigweed interference using the REG PROCEDURE of SAS (SAS 2000).

To formulate the relationship between three independent growth variables measured in our experiment with a dependent variable, multiple regression analysis was carried out for the umbel number per plant (X_1), thousand seeds weight (X_2) and essential oil percentage (X_3) as independent variables and seed yield as a dependent variable. The multiple regression equation is shown as follows:

$$\text{Seed yield (kg ha}^{-1}\text{)} = 0.215 + 0.0400 (X_1) + 0.0425 (X_2) + 0.0888 (X_3)$$

Furthermore, the stepwise regression analysis was also carried out for the data obtained to test the

significance of the independent variables affecting the seed yield as a dependent variable. The resulted stepwise regression equation is shown as follows:

$$\text{Seed yield} = 2.12 + 0.0712 (X_1) + 0.0999 (X_2); R^2 = 80.3$$

Results and discussion

Interaction of studied treatments on umbel number per plant, thousand seeds weight (TSW), seed yield, and essential oil yield on cumin were significant. Results revealed that the highest umbel number per plant of cumin obtained from those seeds treated with micro-elements solution and inoculated with *Azospirillum strain 21* (Fig. 1). In only nutrient-primed seeds umbel number per plant experienced 23% reduction. Whereas, only bio- fertilized seeds produced 11 umbels higher than control. A lot of works as to the application micronutrients have recently been done on the invigoration of seeds to improve the germination rate, hasten emergence time and uniformity of seedling growth in some field crops (Basra *et al.* 2003). Application of bio-fertilizers could increase secondary branches and umbel numbers in some medicinal plants. This result was in good agreement with those reported by El-Ghadban *et al.* (2006) on fennel (*Foeniculum vulgare*). Kandeel *et al.* (2002) found that dual inoculation with symbiotic N₂ fixers (*Azotobacter* and *Azospirillum*) increased plant height, number of branches per plant and dry weight of *Ocimum basilicum*.

When cumin seeds only primed with micro-elements solution, its TSW was not affected by the studied treatments. In bio-fertilized treatments TSW ranged from 3.8 g in *A. brasilense* up to 2.92 g in *A. lipoferum*, but with no significant difference among them. The lowest TSW (2.3 g) were produced from those seeds with not only bio-fertilized but also nutrient primed treatment one, that had 65% reduction in TSW. In nutrient primed seeds, *A. strain of* was better than other strains, but TSW improved from 2.3 g in control to 2.7 g in this bacteria strain (Fig. 2).

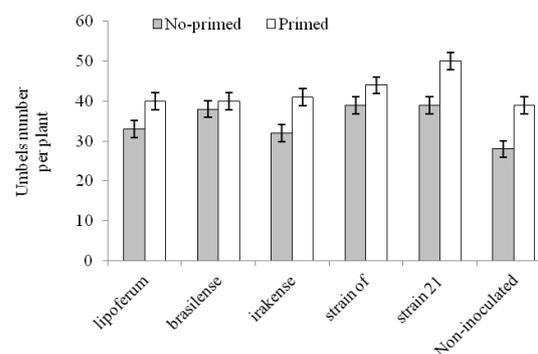
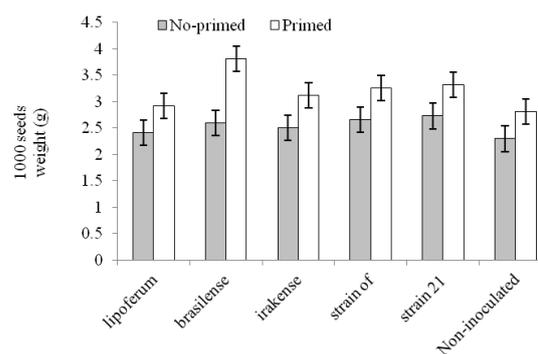
Table 1. Seed yield and essential oil yield of cumin as affected by seed priming methods.

	Treatments	Seed yield (kg ha ⁻¹)	essential oil yield (L ha ⁻¹)
Azospirillum strains	Micro-nutrients solution		
lipoferum	Primed	25.69	0.778
lipoferum	No-primed	16.60	0.391
brasilese	Primed	31.69	0.998
brasilese	No-primed	22.53	0.581
irakense	Primed	33.77	1.07.
irakense	No-primed	16.70	0.412
strain of	Primed	54.06	1.72.
strain of	No-primed	21.16	0.561
strain 21	Primed	57.09	1.67.
strain 21	No-primed	25.97	0.683
Non-inoculated	Primed	24.11	0.704
Non-inoculated	No-primed	11.59	0.256
LSD (5%)	-	6.59	0.071

Effect of studied treatments on seed yield of cumin was indicated in Table 1. In the present study, those seeds treated with *Azospirillum strain 21* and primed with micro-nutrients had higher seed yield (571 kg ha⁻¹), and this value was two times greater than seed yield rate in seeds treated only with *Azospirillum strain 21*. In treatments with greater yield (*A. strain of* or *A. strain 21* × nutrient primed seeds), the yield improved 425 and 455 kg ha⁻¹, respectively, as compared to the control with 116 kg ha⁻¹ yield (Table 1). Simultaneously application of N₂ fixative micro-organisms and lower dose of micro-nutrients on seeds have been reported beneficial for improvement of grain yield in fennel and dill (*Anethum graveolens*) (Gad, 2001). Seed priming has been shown to enhance speed of germination (Deering and Young 2006), reduce the time between sowing and emergence, improve seedling vigor (Harris, 1996) and stand establishment (Arif *et al.* 2005; Ali *et al.* 2007; Diniz *et al.* 2009), and increase yield (Rengel and Graham 1995a, b; Yilmaz *et al.* 1998).

There was no significantly difference among treatments with a view to essential oil percentage when seeds primed with *Azospirillum* strains or micro-nutrients. But increasing of essential oil yield on cumin due to affectability of seed yield from studied treatments was not un-expected (Table 1). In this research essential oil yield on cumin seeds was in range of 17.2 L ha⁻¹ in treatment of seed coating with micro-nutrients × *A. strain of* up to

2.56 L ha⁻¹ in control, as indicated in Table 1. The highest oil yield of fennel was observed with biofertilizer plus a half dose of nitrogen (Mahfouz, S.A. and Sharaf-Eldin, 2007).

**Fig. 1.** Umbels number per plant of cumin as affected by seed priming methods.**Fig. 2.** Thousand seeds weight of cumin as affected by seed priming methods.

The stepwise regression analysis verified that the umbel number per plant and TSW had a marked increasing effect on the seed yield of cumin.

Conclusion

It was concluded from the study that cumin seed and its essential oil yield could be improved by simultaneously seed priming with *Azospirillum strain of* or *Azospirillum strain 21* and nutrient priming with iron, zinc, manganese, boron and molybdenum in semi-arid and cold regions.

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