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*Full Length Research Paper*

# Effect of bio and chemical fertilizers on seed yield and its components of dill (*Anethum graveolens*)

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**To study the effects of bio and chemical fertilizers on seed yield and some of the yield components of dill (*Anethum graveolens* L.), a pot experiment was performed at the Research Station of Faculty of Agriculture, Islamic Azad University, Tabriz Branch, Iran, in 2010. This experiment was conducted factorially based on completely randomized design with three replications. Studied factors consisted of dill landrace populations (Mobarakeh Esfahan and Hamadan), mycorrhiza strains (*Glomus interadices* and *Glomus mosseae* and a non-inoculated one as control), nitrogen fixing biofertilizers (nitroxin, super nitro plus and a non-inoculated one as control) and chemical fertilizers containing nitrogen in urea form and phosphorus in triple super phosphate form (0, 50 and 100% of the recommended dose). Studied traits were number of umbels and seeds per plant, 1000 seed weight and seed yield. The results showed that mycorrhiza application increased the number of seeds per plant and seed yield nearly 32 and 32.5% more than control, respectively. Application of nitrogen fixing biofertilizers also influenced all characteristics studied, significantly. All the characteristics under study except 1000 seed weight were affected by chemical fertilizers. In addition, results revealed that interaction of factors had significant effect on more of the traits under study.**

**Key words:** Mycorrhiza, *Anethum graveolens*, nitrogen fixing biofertilizer.

## INTRODUCTION

Dill (*Anethum graveolens* L.; family Apiaceae) is one of the most important medicinal and aromatic plants due to its estrogenic activities and uses as a carminative, diuretic, anti-inflammatory and antimicrobial. It is a substance which is used to increase the production of milk in humans and other animals (Mirshekari, 2009). Some studies related to medicinal plants in natural and agroecosystems have shown that sustainable agricultural systems is one of the best methods of production of medicinal plants (Sharifi et al., 2002). In addition, impacts which are caused by over application of chemical fertilizers, energies, expenses of their production are the reasons for global tendency toward application of bio-fertilizers (Kannayan, 2002). Mycorrhizal fungi are beneficial microorganisms and thus, have been considered as biofertilizer. Most terrestrial ecosystems depend on mycorrhiza, which promote the establishment, growth and health of plants. Free living nitrogen fixing bacteria like *Azotobacter chrococcum* and *Azospirillum lipoferum*, can not only fix atmospheric nitrogen but can also release plant hormones such as gibberellins and indole acetic acid to stimulate plant growth (Fayez et al., 1985). Kapoor et al. (2004) reported that symbiosis of fennel root with two species of mycorrhizal fungi, including *Glomus macrocarpum* and *Glomus fasciculatum* increased the number of umbels in plant and seed weight. Maheshwari et al. (1991) showed that using *A. chrococcum* alone on palmarosa (*Cymbopogon martinii* var. motia), increased yield by 16% and when applied

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along with 80 kg nitrogen, the yield increased to 29%. Lewis et al. (1995) used double applications of *A. chrococcum* on garlic (*Allium sativum* L.) and inoculated the soil with the bacteria after planting or immersed the cloves with a solution of the bacteria as a pre-planting treatment and then followed these treatments by a soil application 25 days later. They found that the highest profit was obtained by immersing the cloves in a solution with the bacteria prior to planting followed by soil application. Badran and Safwat (2004) and El-Ghadban et al. (2006) understood that using biofertilizer increased fennel growth. Mahapatra et al. (2007) reported average increase of 6% fiber yield of jute with application of NPK along with farmyard manure. According to the investigation, results of Das and Saha (2007) revealed that inoculation of *Azotobacter* and *Azospirillum* on rice in the presence of partial application of nitrogen fertilizer and farmyard manure increased seed yield. Sharaf (1995) showed that inoculation of datura (*Datura stramonium*) and ammi (*Ammi visnaga*) with a mixture of *Azotobacter* and *Azospirillum* with full doses of rock phosphate and inorganic nitrogen fertilizer, in combination with inoculation with vascular arbuscular mycorrhiza (VAM), improved growth of both plants. There is a little information about interaction between nitrogen biological fixing of mycorrhiza. However, Bagyaraj and Menge (1978) recorded a synergistic interaction between *Azotobacter* and vesicular arbuscular mycorrhiza on enhancing dry weight of tomato plants. Roy et al. (2002) reported that a good correlation could be obtained between arbuscular mycorrhiza (AM) fungi population and growth of tea varieties. According to the results of Tyagi et al (1999) research, application of biofertilizers can not only decrease the use of chemical fertilizer by 20 to 50%, but can also simultaneously increase the yield of crop by 10 to 20%. Among the different beneficial soil microbes, *Azospirillum* strains are effective in nitrogen fixing and they can also produce growth promoting substances. The objective of this project was to study the effect of bio and chemical fertilizers on seed yield and components of dill, and thus minimize chemical fertilizers usage.

## MATERIALS AND METHODS

To study the effects of biofertilizers and chemical fertilizers on seed yield and yield components of dill (*A. graveolens*), a pot experiment was performed at the Research Station of the Faculty of Agriculture, Islamic Azad University, Tabriz Branch, Iran, in 2010. A factorial experiment based on completely randomized design with three replications was used in this study. The factors consisted of dill landrace populations (A) (Hamadan: a1 and Mobarakeh Esfahan: a2), mycorrhiza (B) strains (without application of mycorrhiza as control: b1), application of *Glomus interadices*: b2 and *Glomus mosseae*: b3, nitrogen fixing biofertilizers (C) in three levels (without application as control treatment: c1, application of nitroxin: c2 and super nitro plus: c3, and chemical fertilizers (D) containing application of nitrogen (N) in urea form and phosphorus (P) in triple super phosphate form in three levels (0%: d1, 50%: d2 and 100%: d3) based on soil analysis. Nitrogen fixing biofertilizers were applied at two times. First, seeds were inoculated by this biofertilizers and then were dried in shade. It is also applied to plants at its late vegetative stage at the rate of 2 L/ha.

Two hundred grams of mycorrhiza was placed on each pot (filled with 5 kg of soil) and then 12 seeds were planted on mycorrhiza. Chemical fertilizers were also added to the pots along with irrigation after seedling emergence. Traits to be studied in this research were number of umbels and seeds per plant, 1000 seed weight and seed yield. Analysis of variance was used by Statistical Package for Social Sciences (SPSS) and mean compared by using Duncan's multiple range tests. Excel was used to draw the figures.

## RESULTS AND DISCUSSION

Analysis of variance showed that application of mycorrhiza strains significantly affected the number of seeds per plant and seed yield. The effect of nitrogen fixing biofertilizers application was also significant on all characteristics studied. The use of chemical fertilizers was significant on all of characteristics under study except for 1000 seed weight. This study showed that interaction of landrace populations of dill and nitrogen fixing biofertilizers had significant effect on the number of umbel, 1000 seed weight and seed yield. Interaction of landrace populations of dill and chemical fertilizers significantly affected the number of umbel, number of seeds per plant and seed yield. Interaction of mycorrhiza application and nitrogen fixing biofertilizers had significant effect on the number of umbels. Interaction of mycorrhiza application and chemical fertilizers had significant effect on the number of seeds per plant. Furthermore, interaction of application of nitrogen fixing biofertilizers and chemical fertilizers had significant effect on the number of umbel and number of seed per plant. Moreover, interaction of landrace populations of dill, mycorrhiza and nitrogen fixing biofertilizers had significant effect on the number of umbel. In addition, interaction of landrace populations of dill and mycorrhiza and chemical fertilizers and application of biofertilizers and chemical fertilizers had significant effect on the number of umbel, seed and 1000 seed weight. Finally, interaction of all factors was significant on the number of umbel (Table 1).

### Number of umbels per plant

The highest number of umbels per plant (5.45 umbel) is related to $a_1b_3c_3d_1$ treatment (interaction effects of landrace population of Hamadan dill, *G. mosseae* and super nitro plus by without application of chemical fertilizer) and the lowest number (1.52 umbels) is related to control ($a_1b_1c_1d_1$) (Table 2). It can be said that application of biofertilizers such as mycorrhiza with mixed fixing atmospheric nitrogen under non application of chemical fertilizers increased the rate of water uptake of plant and nutrient elements from soil. By using lower amounts of phosphorus, biofertilizers especially

**Table 1.** Analysis of variance of some dill characteristics.

| Source of variation | df | Mean square | | | |
|---|---|---|---|---|---|
| | | Umbels number/plant | Seeds number/plant | 1000 seed weight | Seed yield/pot |
| Landrace populations of dill ( A) | 1 | 1.51 | 0.15 | 0.84 | 0.04 |
| Mycorrhiza (B) | 2 | 0.22 | 265.51** | 0.95 | 5.38** |
| Biofertilizer of nitrogen fixing (C) | 2 | 3.37** | 242.69** | 1.57* | 2.68* |
| Chemical fertilizer (D) | 2 | 1.46* | 96.51** | 0.37 | 2.23* |
| A*B | 2 | 0.52 | 30.9 | 0.6 | 0.01 |
| A*C | 2 | 1.73* | 8.92 | 1.23* | 2.04* |
| A*D | 2 | 5.71** | 50.09* | 0.66 | 1.99* |
| B*C | 4 | 2.05** | 19.64 | 0.4 | 1.2 |
| B*D | 4 | 1.06 | 37.25* | 1.22 | 1.9 |
| C*D | 4 | 3.25** | 44.05* | 0.33 | 0.68 |
| A*B*C | 4 | 2.33** | 25.69 | 0.66 | 0.72 |
| A*B*D | 4 | 3.1** | 79.48** | 1.22** | 1.23 |
| A*C*D | 4 | 0.37 | 18.3 | 0.76 | 1.41 |
| B*C*D | 8 | 1.25* | 49.38** | 1.36** | 0.88 |
| A*B*C*D | 8 | 1.89** | 20.77 | 0.61 | 1.22 |
| Error | 108 | 0.47 | 13.94 | 0.34 | 0.62 |
| CV (%) | - | 24.89 | 16.04 | 30.09 | 24.46 |

*,** and $^{ns}$Significant at 5 and 1% probability levels and non-significant, respectively. CV, Coefficient of variance.

mycorrhiza has the most result in the soil. Also, under the mixed application of mentioned biofertilizer together and without application of chemical fertilizers, the synergistic effect of these two fertilizers increased the umbels number by 72% more than control. Migahed et al. (2004) studied the effect of *Azotobacte*r and *Azospirillum* on celery (*Apium graveolens*) and Tehlan et al. (2004) studied the effect of *Azotobacter* on fennel (*Foeniculum vulgare)* and as a result reported that the number of umbels in these plants was increased significantly. Copetta et al. (2006) and Kapoor et al. (2004) through different researches reported that symbiosis of fennel (*F. vulgare)* root with different mycorrhiza fungi highly increased the umbel number per plant. These results are in agreement with the results this experiment.

## Seed number per plant

Mean of comparisons (Table 3) showed that the highest seed number per plant (903 seed) is related to $a_1b_3d_2$ treatment (interaction effects of landrace population of Hamadan, *G. mosseae* and application of chemical fertilizers in 50% level). The lowest seed number per plant (314 seed) is related to the control, thereby raising the control treatment to 65.23%. It can be said that the symbiosis of mycorrhiza and optimal application of chemical fertilizers from one side improve absorption nutrient elements, especially phosphorus which is important in photosynthesis and seed forming, and raise the growth hormones synthesis from another side. In this research, finally, these reasons make the seed number per plant to increase more than the control treatment. Increasing active surface of the root system for absorbing nutrients from soil (Kapoor et al., 2007), increases photosynthesis, resistance to water deficit, salinity stress, pests and diseases resistance and soil structure improvement, especially in phosphorus, lack conditions are the benefits of mycorrhiza fungi in plants (Copetta et al., 2006) which led to the best plant growth. The comparison of the triple interaction of BCD showed that the highest seed number per plant (1163 seed) is related to $b_3c_3d_2$ treatment (the mixed application of *G. mosseae,* super nitro plus and chemical fertilizer in 50% level), and the least number per plant (263 seed) is obtained for the control treatment (Table 4). It seems that the application of biofertilizers of mycorrhiza and nitrogen fixing at the same time and in different times have the highest synergistic effect on each other. Also, because of suitable application rate of chemical fertilizers, assembling effect of mentioned factors could increase seed rate of plant more than control treatment up to 77.39%. Studying biofertilizers including mycorrhiza, *Azospirillum* and *Azotobacter* on nigella seed (*Nigella sativa* L.), a medicinal plant, showed that seed number per plant under the application of biofertilizers at the same time condition increased very much (Khorramdel et al., 2010), which is accorded to study results. Whereas the seed per plant determines the plant sink capacity, and in this research cleared that by the application of biofertilizers at

**Table 2.** Interaction of landrace populations of dill, mycorrhiza, nitrogen fixing biofertilizers and chemical fertilizers on the number of umbels per plant.

| Treatment | Number of umbels/plant | Treatment | Number of umbels/plant |
|---|---|---|---|
| a1b1c1d1 | 1.52$^{p}$ | a2b1c1d1 | 2.94$^{b-o}$ |
| a1b1c1d2 | 1.83$^{l-p}$ | a2b1c1d2 | 1.97$^{j-p}$ |
| a1b1c1d3 | 2.90$^{b-p}$ | a2b1c1d3 | 3.50$^{b-h}$ |
| a1b1c2d1 | 3.83$^{b-e}$ | a2b1c2d1 | 2.59$^{e-p}$ |
| a1b1c2d2 | 2.89$^{b-p}$ | a2b1c2d2 | 2.29$^{g-p}$ |
| a1b1c2d3 | 3.33$^{b-j}$ | a2b1c2d3 | 2.14$^{h-p}$ |
| a1b1c3d1 | 2.61$^{e-p}$ | a2b1c3d1 | 4.17$^{bc}$ |
| a1b1c3d2 | 2.82$^{c-p}$ | a2b1c3d2 | 2.04$^{i-p}$ |
| a1b1c3d3 | 1.92$^{k-p}$ | a2b1c3d3 | 2.18$^{g-p}$ |
| a1b2c1d1 | 2.91$^{b-p}$ | a2b2c1d1 | 2.20$^{g-p}$ |
| a1b2c1d2 | 2.55$^{e-p}$ | a2b2c1d2 | 3.55$^{b-g}$ |
| a1b2c1d3 | 2.76$^{d-p}$ | a2b2c1d3 | 3.37$^{b-j}$ |
| a1b2c2d1 | 2.35$^{f-p}$ | a2b2c2d1 | 1.74$^{n-p}$ |
| a1b2c2d2 | 3.81$^{b-e}$ | a2b2c2d2 | 1.98$^{j-p}$ |
| a1b2c2d3 | 1.88$^{l-p}$ | a2b2c2d3 | 2.08$^{i-p}$ |
| a1b2c3d1 | 4.2$^{b}$ | a2b2c3d1 | 2.75$^{d-p}$ |
| a1b2c3d2 | 2.06$^{i-p}$ | a2b2c3d2 | 3.10$^{b-n}$ |
| a1b2c3d3 | 3.15$^{b-m}$ | a2b2c3d3 | 4.11$^{b-d}$ |
| a1b3c1d1 | 3.22$^{b-l}$ | a2b3c1d1 | 1.97$^{j-p}$ |
| a1b3c1d2` | 3.21$^{b-l}$ | a2b3c1d2 | 1.77$^{m-p}$ |
| a1b3c1d3 | 2.37$^{f-p}$ | a2b3c1d3 | 3.53$^{b-h}$ |
| a1b3c2d1 | 3.0$^{b-o}$ | a2b3c2d1 | 2.17$^{g-p}$ |
| a1b3c2d2 | 2.73$^{d-p}$ | a2b3c2d2 | 3.28$^{b-k}$ |
| a1b3c2d3 | 1.64$^{o-p}$ | a2b3c2d3 | 2.29$^{g-p}$ |
| a1b3c3d1 | 5.45$^{a}$ | a2b3c3d1 | 2.14$^{h-p}$ |
| a1b3c3d2 | 2.61$^{e-p}$ | a2b3c3d2 | 2.18$^{g-p}$ |
| a1b3c3d3 | 3.44$^{b-i}$ | a2b3c3d3 | 3.72$^{b-f}$ |

Means containing similar letters in each column are not significantly different at 5% level of probability according to Duncan's test. a1, a2, Landrace population of Hamedan and Esfahan Mobarakeh, respectively; b1, without application of mycorrhiza; b2, *G. interadices*, and b3, *G. mossaea*; c1, without application of nitrogen fixing bio fertilizer; c2: nitroxin; c3, super nitro plus; d1, d2, d3 application of chemical fertilizers at 0, 50 and 100% level respectively.

the same time the seed number per plant increased. Therefore, when the seed number increase, the plant will have larger sink to receive more of the photosynthesis materials. Finally, seed yield will be more in the presence of biofertilizers.

### 1000 seed weight

The mean comparisons of interaction of AC showed that the highest 1000 seed weight (2.22 g) is related to $a_2c_2$ treatment (landrace population of Mobarakeh Esfahan under the condition of nitroxin application) and the least number (1.6 g) is related to $a_2c_1$ treatment (landrace population of Mobarakeh Esfahan dill without application of nitrogen fixing biofertilizer) (Table 5). Atmospheric nitrogen fixing biofertilizers such as nitroxin contain useful bacteria such as *Azospirillum* and *Azotobacter* which can produce anti fungi combinations against plant diseases. Thus fortify seedling growth and finally improve plant growth (Chen, 2006). On the other hand, *Azospirillum* can not only fix atmospheric nitrogen, but can also cause root growth by producing growth stimulant materials. In this way, rate of water and nutrient absorption increase (Tilak et al., 2005). These bacteria have therefore, positive effects on 1000 seed weight. The mean of comparisons of the third interaction of ABD (landrace populations of dill, mycorrhiza and chemical fertilizer) showed that the highest 1000 seed weight is related to $a_1b_3d_2$ (2.48 g) rather than the other treatments and the lowest 1000 seed weight (1.4 g) is related to control treatment (Table 3).

Results showed that the application of mycorrhiza species *G. mosseae* along with chemical fertilizer at

**Table 3.** Interaction of landrace populations of dill, mycorrhiza and chemical fertilizers on the number of seeds per plant and 1000 seed weight.

| Treatment | Number of seeds/plant | 1000 grain weight (g) |
|---|---|---|
| a1b1d1 | 314.0$^{o}$ | 1.40$^{e}$ |
| a1b1d2 | 453.3$^{j}$ | 1.57$^{de}$ |
| a1b1d3 | 422.0$^{k}$ | 1.66$^{c-e}$ |
| a1b2d1 | 586.9$^{f}$ | 2.30$^{a-c}$ |
| a1b2d2 | 382.9$^{n}$ | 2.01$^{a-e}$ |
| a1b2d3 | 711.8$^{c}$ | 2.13$^{a-d}$ |
| a1b3d1 | 714.7$^{c}$ | 1.92$^{a-e}$ |
| a1b3d2 | 903.0$^{a}$ | 2.48$^{a}$ |
| a1b3d3 | 536.2$^{h}$ | 2.02$^{a-e}$ |
| a2b1d1 | 450.5$^{j}$ | 1.54$^{de}$ |
| a2b1d2 | 414.8$^{m}$ | 2.15$^{a-d}$ |
| a2b1d3 | 551.4$^{g}$ | 1.57$^{de}$ |
| a2b2d1 | 428.9$^{l}$ | 2.10$^{a-d}$ |
| a2b2d2 | 599.9$^{e}$ | 1.77$^{b-e}$ |
| a2b2d3 | 705.7$^{d}$ | 1.57$^{de}$ |
| a2b3d1 | 492.1$^{i}$ | 1.90$^{a-e}$ |
| a2b3d2 | 600.2$^{e}$ | 2.29$^{a-c}$ |
| a2b3d3 | 727.4$^{b}$ | 2.02$^{a-e}$ |

Means containing similar letters in each column are not significantly different at 5% level of probability according to Duncan's test. a1, a2, Landrace population of Hamadan and Esfahan Mobarakeh, respectively; b1, non application of mycorrhiza; b2, *G. interadices*, and b3, *G. mosseae*; d1, d2, and d3 application of chemical fertilizers at 0, 50 and 100% level, respectively.

level increased 1000 seed weight up to 43.32% as compared to the control treatment. This shows that suitable amount of chemical fertilizer is necessary for initial root growth and forming fungi hypha. Harrison (2005) reported that symbiosis of mycorrhiza with plants improves phosphorus availability when it is in shortage condition. Therefore, it could be concluded that mycorrhiza increases absorption of phosphorus, nitrogen, zinc, copper, iron and magnesium. It also promotes synthesis of plant hormones, especially gibberellin which is effective in increasing 1000 seed weight of dill. The mean comparison of triple interaction of BCD(mycorrhiza, atmospheric nitrogen biofertilizer and chemical fertilizer) showed the highest 1000 seed weight(2.66 g) produced by $b_3c_2d_2$ treatment (interaction effect of *G. mosseae,* nitroxin and chemical fertilizer at 50% level) and the lowest (1.22 g) produce by control treatment ($b_1c_1d_1$) (Table 4). It seems that inoculation of biofertilizers and using 50% of chemical fertilizers increase rate and duration of photosynthesis (Richter et al., 2005). Khorramdel et al. (2010) concluded that the inoculation of nigella seed (*N. sativa* L.) with biofertilizers mycorrhiza and nitrogen fixing increase 1000 seed weight. These results are in confirmation with this experiment.

**Table 4.** Means of interaction of mycorrhiza, biofertilizer of nitrogen fixing and chemical fertilizer on the number of seed per plant and 1000 seed weight.

| Treatment | Number of seeds/plant | 1000 grain weight (g) |
|---|---|---|
| b1c1d1 | 263.0$^{w}$ | 1.22$^{e}$ |
| b1c1d2 | 426.3$^{t}$ | 1.9$^{a-e}$ |
| b1c1d3 | 467.5$^{q}$ | 1.74$^{b-e}$ |
| b1c2d1 | 365.0$^{v}$ | 1.93$^{a-e}$ |
| b1c2d2 | 390.2$^{u}$ | 2.34$^{a-c}$ |
| b1c2d3 | 508.8$^{m}$ | 2.19$^{a-d}$ |
| b1c3d1 | 518.8$^{k}$ | 1.70$^{c-e}$ |
| b1c3d2 | 485.8$^{o}$ | 1.76$^{b-e}$ |
| b1c3d3 | 513.8$^{l}$ | 1.91$^{a-e}$ |
| b2c1d1 | 367.3$^{v}$ | 1.93$^{a-e}$ |
| b2c1d2 | 479.3$^{p}$ | 1.34$^{de}$ |
| b2c1d3 | 708.5$^{f}$ | 1.68$^{c-e}$ |
| b2c2d1 | 365.8$^{v}$ | 2.62$^{a}$ |
| b2c2d2 | 462.5$^{r}$ | 1.74$^{b-e}$ |
| b2c2d3 | 506.3$^{m}$ | 1.61$^{c-e}$ |
| b2c3d1 | 790.5$^{c}$ | 2.05$^{a-d}$ |
| b2c3d2 | 532.3$^{j}$ | 2.53$^{ab}$ |
| b2c3d3 | 911.5$^{b}$ | 1.55$^{c-e}$ |
| b3c1d1 | 455.2$^{s}$ | 2.17$^{a-d}$ |
| b3c1d2 | 563.3$^{i}$ | 2.64$^{a}$ |
| b3c1d3 | 759.2$^{d}$ | 1.41$^{de}$ |
| b3c2d1 | 725.8$^{e}$ | 1.71$^{c-e}$ |
| b3c2d2 | 528.3$^{j}$ | 2.66$^{a}$ |
| b3c2d3 | 497.7$^{n}$ | 2.32$^{a-c}$ |

Means containing similar letters in each column are not significantly different at 5% level of probability according to Duncan's test. b1, Without application of mycorrhiza; b2, *G. interadices*, and b3, *G. mosseae*; c1, without application of nitrogen fixing biofertilizer; c2, nitroxin; c3, super nitro plus; d1, non application of chemical fertilizers; d2, d3 application of chemical fertilizers at 50 and 100% level, respectively.

## Seed yield

The comparisons of mean showed that the highest seed yield (12.26 g) was obtained when *G. mosseae* was used. Seed yield under this condition was 11.91% higher than the ones where inoculation was not used (Figure 1).

It can be said that symbiosis of mycorrhiza with plants stimulates degradation of soil organic materials. Mycorrhiza by different mechanisms such as production of phosphatase enzyme, indole acetic acid, etc., increasing plant resistance in different stresses can cause plant growth and seed yield to increase. Ilbas and Sahin (2005) also mentioned that symbiosis mycorrhiza with soybean plant (*Glycine max* L.) increase root growth and seed yield more than control treatment.

Results show that (Table 5) the highest seed yield (13.1 g) is related to $a_2c_3$ treatment (the application of Mobarakeh Esfahan) and the lowest (8.48 g) is related to

**Table 5.** Interaction of landrace populations of dill and nitrogen fixing biofertilizers on 1000 seed weight (g) and seed yield per plant.

| Treatment | 1000 seed weight (g) | Seed yield/plant(g) |
|---|---|---|
| a1c1 | 1.96[ab] | 8.48[e] |
| a1c2 | 2.02[ab] | 11.24[c] |
| a1c3 | 2.08[ab] | 12.04[b] |
| a2c1 | 1.60[c] | 10.37[d] |
| a2c2 | 2.22[a] | 12.01[b] |
| a2c3 | 1.81b[c] | 13.1[a] |

Means containing similar letters in each column are not significantly different at 5% level of probability according to Duncan's test. a1,a2, Landrace population of Hamadan and Esfahan-Mobarakeh, respectively; c1, without application of nitrogen fixing bio fertilizer; c2, nitroxin; c3, super nitro plus.

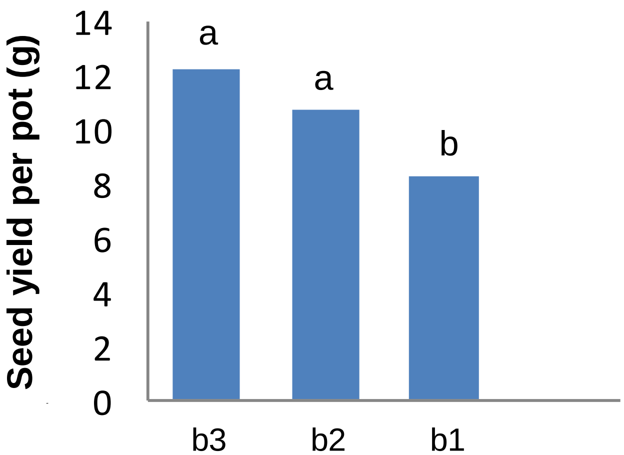


**Figure 1.** Effect of mycorrhiza on seed yield.

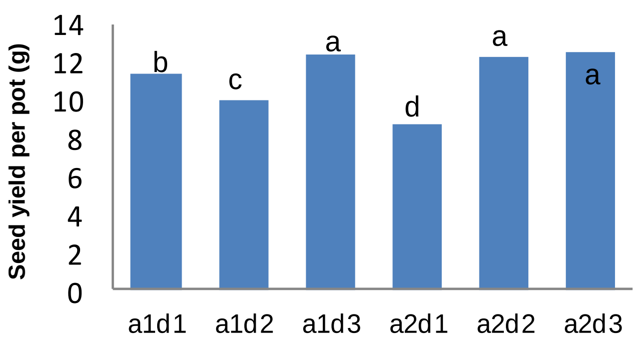


**Figure 2.** Interaction of landrace population of dill and chemical fertilizer on seed yield per pot. a1: Landrace population of Hamadan; a2: Landrace population of Mobarakeh Esfahan; b1: Without application of mycorrhiza; b2: Application of *G. interadices*; b3: Application of *G. mosseae*; d1: Without application chemical fertilizer; d2: Application of chemical fertilizer at 50% level; d3: Application of chemical fertilizer at 100% level.

super nitro plus biofertilizer in landrace population of $a_1c_1$ treatment (without application of nitrogen fixing biofertilizer to landrace population of Hamadan). It seems that the application of nitrogen fixing biofertilizers, especially super nitro plus, because of having bacteria such as *Azospirillum*, soil pathogenic factors like *Bacillus subtilis* and growth stimulate bacteria (*Pseudomonas fluorescens*), increase plant growth and seed yield by producing and synthesizing growth stimulate combi-nations. According to researches, Tehlan et al. (2004) on fennel (*F. vulgare*) inoculation by *Azotobacter* increase seed yield of fennel (*F. vulgare*) significantly. Their experiment results in agreement with this experiment.

Comparisons of mean dual interaction of AD (landrace populations of dill and chemical fertilizers) on seed yield indicates that $a_2d_2$ and $a_1d_3$ treatments as far as seed yield statistically were in the same group, but the highest seed yield (12.56 g) is related to $a_2d_3$ treatment (application of chemical fertilizer at 100% level on landrace population of Mobarakeh Esfahan) and the lowest was obtained from $a_2d_1$ treatment (without application of chemical fertilizer to landrace population of Hamadan) (Figure 2). Plants need nutrient elements, especially phosphorus and nitrogen for their growth, metabolic activities and for photosynthesis. Therefore, when the nutrient elements are abundant in the root environment, plant growth rate increase and photosyn-thesis will be done in high effectiveness rate. This study revealed that application of chemical fertilizers at 100% level increase seed yield. It is said that enough application of chemical fertilizers cause photosynthesis, plant growth and finally seed yield to increase.

## Conclusion

This study had shown that using mycorrhiza, nitrogen fixing biofertilizers along with lower dose of chemical fertilizers resulted in the greatest yield components and seed yield of dill.

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### REFERENCES

Badran FS, Safwat MS (2004). Response of fennel plants to organic manure and bio-fertilizers in replacement of chemical fertilization. Egyptian J. Agric. Res. 82(2):247-256.

Bagyaraj DJ, Menge JA (1978). Interaction between a VA mycorrhiza and *Azotobacter* nd their effects on rhizosphere microflora and plant growth. New Phytol. 80:567-573.

Chen J (2006). The combined use of chemical and organic fertilizers and/or biofertilizer for crop growth and soilfertility. International Workshop on Sustained Management of the Soil-Rhizosphere System for Efficient Crop Production and Fertilizer Use. October, 16-20. Thailand p.11.

Copetta A, Lingua G, Berta G (2006). Effect of three AM fungi on growth, distribution of glandularb hairs, and essential oil production in *Ocimum basilicum* L. var. Genovese. J. Mycorrhiza 16:485-494.

Das AC, Saha D (2007). Effect of Diazotrophs on the mineralization of organic nitrogen in the rhizosphere soils of rice *(Oryza sativa*). J. Crop Sci. 84:69-74.

El-Ghadban EAE, Shalan MN, Abdel-Latif TAT (2006). Influence of biofertilizers on growth, volatile oil yield and constituents of fennel (*Foeniculum vulgare* Mill.). Egyptian J. Agric. Res. 84(3):977-992.

Fayez M, Emam NF, Makboul HE (1985). The possibleuse of nitrogen fixing *Azospirilum* as biofertilizer for wheatplants. Egyptian J. Microbiol. 20(2):199-206.

Harrison MJ (2005). Signaling the arbuscular mycorrhizal symbiosis. Ann. Rev. Microbiol. 59:19-42.

Kannayan S (2002). Biofertilizer for sustainable crop production. In biotechnol. biofertilizers, Eds. Kannayan, S. Narosa Publishing House, New Delhi, India pp.9-49.

Kapoor R, Chaudhary V, Bhatnagar, AK (2007). Effect of arbuscular mycorrhiza and phosphorus application on artemisinin concentration in *Artemisia annua* L. Mycorrhiza 17:581-587.

Kapoor R, Giri B, Mukerji KG (2004). Improved growth and essential oil yield quality in (*foeniculum vulgare* Mill) on mycorrhizal inoculation supplemented with P-Fertilizer. Bioresour. Technol. 93:307-311.

Korramdel S, Khochaki A, Nasiri-Mahallati M, Ghorbani R (2010). Effect of bofertilizer on yield and yield companent of nigella seed (*Nigella sativa* L.). Iranian J. Field Crops Res. 8(5):768-766.

Lewis AL, Dominguez LO, Munoz OS (1995). Effect of time and method of *Azotobacter chrococcum* applicationon the cultivation of garlic (*Allium sativum* L.) cv. Vietnamita.Int. Am. Soc. Trop. Hort. 39:27-32.

Mahapatra BK, Maiti S, Satpathi M (2007). Relative performance of complex and straight chemical fertilizer in conjunction with or without organic manure in potato-Jute crop sequence. J. Crop Weed 3:69-74.

Maheshwari SK, Gangrade SK, Trivedi KC (1991). Comparative response of palmarosa to *Azotobacter* and nitrogen under rainfall and irrigated swards. Indian Perfume 35(2):308-311.

Migahed HA, Ahmed AE, Abd El-Ghany BF (2004). Effect of different bacterial strains as biofertilizer agents on growth, production and oil of *Apium graveolens* under Calcareous soil. J. Agric. Sci. 12:511-525.

Mirshekari B (2009). Production of medicinal and spice crops. Islamic Azad Univ. Tabriz Branch Publisher. p. 186.

Richter J, Stutzer M, Schellenberg I (2005). Effects of mycorrhiza on the essential oil content and composition of aroma components of marjoram (*Marjorana hortensis*), thym (*Thymus vulgaris* L.) and caraway (*carum carvi* L.).36 th International Symposium on Essential Oils, 4-7 September, Budapes, Hungary.

Roy AK, Kumari R, Chakraborty BN, Chakraborty U (2002) VA mycorrhiza in relation to growth of different tea varieties. Mycorrhiza News 14:9-11.

Sharaf MS (1995). Response of some medicinal plants to inoculation with a symbiotic N2-fixers. Ph.D. Thesis, Faculty of Agriculture. Ain Shams University Egypt.

Sharifi Ashorabadi A, Normohammadi GH, Matin A, Ghalavand A, Lebaschi MH (2002). Comparison efficiency consumption energy in different method of soil fertility (Chemical, Integrated, Organic). J. Res. Constr. Forest Rangeland 57:91-97.

Tehlan SK, Thakral KK, Nadal JK (2004). Effect of *Azotobacter* on plant growth and seed yield of fennel (*Foeniculum vulgare* Mill.). Haryana J. Hort. Sci. 33(3/4):287-288.

Tilak KVBR, Ranganayaki, Pal KK, De R, Saxena AK, Shekhar C, Shilpi A, Tripathi AK, Johri BN (2005). Diversity of plant growth and soil health supporting bacteria. Curr. Sci. 89:136-150.

Tyagi PK, Hooda MS, Singh R (1999). Biofertilizer in integrated plant nutrition system. Indian Farmers Times 17(6):13.