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# Influence of Zn and ferrous sulfate on yield and yield component of *Phaseolus vulgaris*

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**Abstract**

This study was conducted to investigate the effect of various levels of zinc sulfate and ferrous sulfate fertilizers on biological yield, plant height and stem diameter of pod in a bush and the length of main root of pinto bean cultivar (*phaseolus vulgaris*). A field experiment was conducted in 2013 in Sarvak region of Boyer-Ahmad, Iran. It was a factorial study on the basis of randomized complete block design with treatments including three levels of ferrous sulfate (0, 50, 100 kg / ha) and three levels of zinc sulfate (0,50,100 kg / ha). Data analyses indicated the interaction effect of zinc sulfate and ferrous sulfate on biological yield and stem diameter were significant at 5% level, also observed interaction of zinc sulfate and ferrous sulfate on plant height, economic yield and weight of thousand grain weights were significant at 1% level. Treatments of $fe_0$ $zn_{100}$, $fe_{100}$ $zn_0$ produced the maximum (12303 t/ha) and minimum (6030 t/ha) of biological yield respectively.

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## Introduction

Common bean *(Phaseolus vulgaris)* is an important source of food throughout the world and contains protein, fiber and vitamins that increased food value of this product (Dursum, 2007; Akhshi *et al.,* 2014; Sadeghipour and Aghaei, 2012). It is one of the most important crops in terms of both economy and nutrition and is cultivated in different regions of Iran including the Markazi, Lorestan and Isfahan provinces (Asteraki *et al.,* 2012). Different types of common bean by, 20-25% protein and annual production of more than 19.3 million tons are in the first place of pulses production (Abbasi *et al.,* 2013). According to FAO (2008) report, global average of beans yield is 568 kg/ha. Total area under cultivation in Iran is 115833 ha and total production is 218858 Tons of which 97.1% is cultivated as irrigated and 2.9% as dry farming (Fao, 2008; Gharib Ardakani and Faraji, 2013).

Based on the past studies, the optimal growth of plant as well as the maximum yield and quality demand a sufficient and balanced level of micro elements and macro elements in soil.

Deficiency of micronutrients in lands under cultivation is a global concern, and millions of hectares of cultivable lands around the world suffer micronutrients shortage, and about 40% of people around the world suffer micronutrients shortage, especially zinc (Welch *et al.,* 1991). In agriculture practices fertilizer is an important source to increase crop yields. Among fertilizer application methods, one of the most important methods of application is foliar nutrition because foliar nutrients facilitate easy and quick consumption of nutrients by penetrating the stomata or leaf cuticle and enters the cells (Latah and Nadanassababady, 2003; Rahman *et al.,* 2014).

The main reason for iron deficiency is the abundance of bicarbonate in soil. Most soils in Iran have considerable bicarbonate, so the plant roots. Creating a special condition around it, decreases soil and provides the needed iron. Heavy irrigation and any factor decreasing soil ventilation increase carbon dioxide concentration of soil, as a result, the iron absorption decreases (Zohrevand, 2013).

Common bean is very sensitive to Zn deficiency particularly under high light intensity (Marschner and Cakmak, 1989). Results of Ghanepour *et al* (2014) showed thatPhysiological elements underline the necessity of improved Zn nutrition in common bean crop.

Zinc always *has* been a significant mineral element for plant, that carry out in physiological activities such photosynthesis, forming fructose, protein synthesis, fertility, growth, and resistance to diseases. Calcareous soils with high PH, rare organic matters, and high levels of bicarbonates in irrigation water are among factors that limit consumption of this element for plants and impose huge damages on production level and quality. Application and mixture of substances such as plant residues, animal manures, compost, and micronutrients as iron and zinc can enhance yield and yield components of plant (Das *et al.,* 2014; yang *et al.,* 2014; Akinyele and Shokunbi, 2015). Hemmati (2004) indicated that the maximum yield (1847kg/He) was reached through application of 50 kg/ha of ferrous sulfate and 40 kg/ha of zinc sulfate and manganese in bean farm; this amount proved a 13.5% of yield increase in comparison to control treatment. Kulig (1996), using 2 to 3 liters of a commercial fertilizer called Flovit containing trace elements, observed significant increase in yield, pod number of plant and kernel number of each pod. Inside the country there have not been many studies on trace elements application for bean. Malakouti (1999) reported that the optimal application of fertilizers particularly trace elements in legumes farms, resulted in 143% increase in yield and improvement of protein level.

Given the importance of *Phaseolus vulgaris* in the Middle East and necessity of using micronutrients in agricultural land and irreparable damages caused by the lack of micronutrients in the plant; the current study was done to investigate the effects of iron and zinc on yield and yield component of *Phaseolus* *vulgaris*.

## Materials and methods

*Plan locality*

The experiment was conducted with nine treatments and three replications in 2013 in Boyer-Ahmad city, Iran (Sarvak area). The treatments of iron sulfate (20%) at three levels of 0, 50,100 kg/ ha ($Fe_0$.$Fe_{50}$, $Fe_{100}$) and zinc sulfate (24%) at three levels of 0, 50, 100 kg/ha ($Zn_0$, $Zn_{50}$, $Zn_{100}$) were applied based on factorial design in randomized complete block designs. The treatments included $Zn_{50}$ $Fe_{100}$, $Zn_{100}$ $Fe_{50}$, $Zn_{100}$ $Fe_{100}$, $Zn_{50}$ $Fe_{50}$, $Zn_0$ $Fe_{100}$, $Zn_0$ $Fe_{50}$, $Zn_{100}$ $Fe_0$, $Zn_{50}$ $Fe_0$, $Zn_0$ $Fe_0$, and pinto bean cultivar, with thousand grain weights 430 grams. Each plot area was 10 square meters (1×10). Seeds were planted with 10 cm distance on the rows with 15 cm distance. Based on soil test, the basic fertilizer (triple super phosphate, potassium sulfate, and urea) was 180 kg/ha. Potassium, phosphor, one third of urea fertilizers, and experimental fertilizers were integrated into the soil at the time of planting (23.06.2013). The remaining urea fertilizer was sprayed over the farm twice prior to harvesting. The data analysis was performed via SAS software and mean scores were compared through Dunkan's test. Analyses of combined soil samples taken from the farm, before cultivation, were shown in Table 1 (NikEghbali Sisakht, 2013).

*Soil analysis*

The results obtained from the soil sample analysis, taken from experimental field prior to planting, are demonstrated in table 1.

*Measured traits*

*Biological yield*

The term biological yield is used to show the accumulation of dry matter in plant system. In order to estimate biological yield, one square meter of each plot was chosen and harvested. The crops were weighed after drying and then biological yield was calculated for each hectare.

*Plant height*

The length of plant was measured by a ruler to the point where the main stem had grown.

*Stem diameter*

Before harvesting, the stem diameters of 14 plants adjacent to the soil surface were randomly chosen and measured by a caliper in different treatments.

*Economical yield*

Yield is often estimated as kilogram per hectare. After the plants were fully grown, one square meter in the center of each plot was harvested. Seed number and yield was determined after drying.

*Thousand grain weights*

At the time of harvesting, a random number of plant pods were chosen from one square meter of each plot. They were air dried and 1000 kernels of harvested sample were weighed by a sensitive digital scale and their grain weight was calculated.

## Results

*Biological yield*

Based on the results of variance analysis, effect of ferrous sulfate on biological yield mean was significant at 1% level lonely, whether zinc sulfate lonely and interaction of their factors had significant at 5% level on biological yield mean of wax bean (table2).

The comparison of data mean values indicated that effects of different levels of ferrous sulfate on biological yield mean were significant. Non-ferrous sulfate treatment with 1001 grams yield per square meter proved higher than other treatments and occupied classA (table 3). The comparison of mean values demonstrated that effects of different levels of zinc sulfate on biological yield mean were significant. Treatments of applying Zn 50kg/Hec and Zn 100kg/Hec with yields of 917.44 and 965.33 gr/m respectively proved higher than non zinc sulfate treatment with 782 gr/m, being placed at classes A and B respectively.

Compared of mean values for interaction effect of ferrous sulfate and zinc sulfate indicated that there exists a significant difference among treatments in terms of biological yield. Non ferrous sulfate treatment along with 100 kilograms of zinc sulfate ($Fe_0Zn_{100}$) per hectare and yield mean of 1230.33 $Gr/m^2$ was higher than any other treatment and occupied class A. This treatment showed 27% product increase in compare to the control treatment ($Fe_0Zn_0$) (table 4).

**Table 1.** The results obtained from the analysis of the farm soil taken from the location of field experiment before planting.

| Soil traits | Rate | Soil traits | Rate |
|---|---|---|---|
| Depth (cm) | 0-30 | Clay percentage | 43 |
| Saturation percentage (sp) | 62 | Silt percentage | 37 |
| The electrical conductivity ($d_{s/m}$) | 0.5 | Sand percentage | 20 |
| Saturate mud acidity (PH) | 8.1 | Soil texture | Clay (c) |
| Total neutralizing value (percentage) | 21 | Organic carbon percentage | 0.6 |
| Total Nitrogen percentage | 0.06 | Absorbable phosphor (mg/kg) | 12 |
| Absorbable potassium percentage (mg/kg) | 401 | | |

*Plant height*

Variance analysis (table 2) demonstrated that the application of ferrous sulfate and zink sulfate lonely and interaction of them had significant effect on plan height at 1% level of probability.

Results from comparing the mean of data showed that effects of different levels of ferrous sulfate on plant height were not worthy. Non ferrous sulfate treatment with height mean of 76.67 cm proved higher than other treatments and was placed at class A. However, treatments of applying 50 and 100 kilograms of ferrous sulfate per hectare with plant heights of 71 and 66.44cm respectively were all placed at class B (table 3). Comparing mean values demonstrated that different levels of zinc sulfate were not significantly effect on plant height. Treatments of 0, 50, and 100 kg of zinc sulfate per hectare with plant heights of 75, 71, and 69.56 cm respectively, were all placed at class B (table 3).

**Table 2.** The variance analysis of mean square for effects of different levels of ferrous sulfate and zinc sulfate on yield and yield components of wax bean cultivar.

| Alteration sources | Degree of freedom | Mean square | | | | |
|---|---|---|---|---|---|---|
| | | Biological yield | Plant height | Stem diameter | Economic yield | Weight of one Thousand seeds |
| Block | 2 | 903.26$^{ns}$ | 8.48$^{ns}$ | 0.29$^{ns}$ | 1193.59$^{ns}$ | 492.59$^{ns}$ |
| Ferrous sulfate | 2 | 99329.15** | 159.37** | 1.81** | 24022.70** | 370.37* |
| Zinc sulfate | 2 | 81374.48* | 68.26$^{ns}$ | 0.06 | 720.48$^{ns}$ | 803.70* |
| Ferrous* zinc sulfate | 4 | 68796.15* | 480.76** | 0.98* | 5951.43** | 1420.37** |
| Error | 16 | 282188.81 | 31.23 | 4.59 | 1167.71 | 159.26 |
| Coefficient of variation | | 14.78 | 14.78 | 9.87 | 7.11 | 2.91 |

*ns* non-significant *significant at 5% level **significant at 1% level.

Mean values of the interaction effect of factors showed that the treatments differed significantly in terms of plant height. Non ferrous sulfate treatment along with applying 50 kg of zinc sulfate per hectare ($Fe_0Zn_{50}$) with plant height mean of 90 cm proved higher than other treatments, occupying class A.

*Stem diameter*

Variance analysis (table 2) indicated that applying ferrous sulfate on stem diameter and the interaction of ferrous sulfate and zinc sulfate were significantly effective at 1% and 5%, respectively. However, the application of zinc ferrous was not significant.

The mean comparisons showed that influences of different levels of ferrous sulfate on stem diameter mean were significant. The treatment of applying 50 kg of ferrous sulfate per hectare with stem diameter mean of 5.94 mm proved higher than other treatments and occupied class A (table 3). The mean comparisons showed that effects of different levels of zinc sulfate on stem diameter were not significant. Treatments of 0, 50 and 100 kg of ferrous sulfate per hectare with stem diameters of 5.5, 5.44, and 5.33 mm, respectively were all placed at class A (table 3).

The interaction effect of ferrous sulfate and zinc sulfate had different significantly effect on stem diameter. The treatment effect of applying 50 kg ferrous sulfate per hectare along with 0kg zinc sulfate per hectare ($Fe_{50}Zn_0$) with stem diameter of 6.67 mm was higher than other treatments and occupied class A. This treatment showed 28 % stem diameter increase in compared to the control treatment (table 4).

**Table 3.** The results for simple effects of different levels of ferrous sulfate and zinc sulfate on yield and yield components of wax bean cultivar.

| Examined factors | Unit (kg/he) | Biological yield (gr/m²) | Plant height (cm) | Stem diameter (mm) | Weight of one Thousand seeds (Gr) | grain yield (gr/m²) |
|---|---|---|---|---|---|---|
| Ferrous sulfate | 0 | 1001[a] | 76.67[a] | 5.17[b] | 436.67[a] | 508.78[a] |
| | 50 | 870.67[ab] | 68.44[b] | 5.94[a] | 436.67[a] | 511.89[a] |
| | 100 | 793.11[b] | 71[b] | 5.17[b] | 425.56[a] | 420.89[b] |
| Zinc sulfate | 0 | 782[b] | 71.56[a] | 5.5[a] | 423.33[b] | 471.44[a] |
| | 50 | 917.44[a] | 75[a] | 5.44[a] | 433.33[ab] | 480.78[a] |
| | 100 | 965.33[a] | 69.56[a] | 5.33[a] | 442.22[a] | 489.33[a] |

Means scores of each column with at least one shared letter, are not significantly different.

*Weight of one Thousand seeds*

Based on the results of the table of variance analysis ferrous sulfate and zinc sulfate had significant effect on *Weight of one Thousand seeds* at 1%, while interaction of their factors had significant effect on *Weight of one Thousand seeds* at 5%.

The result of comparison between the means indicated that were not significantly different between different levels of ferrous sulfate on thousand grain weights. (table 3). The results of means comparison indicated that effects of various levels of zinc sulfate on thousand grain weights were significantly different. The highest thousand grain weights, (442.22) derived by using 100 kg/ ha zinc sulfate was placed at class A. The treatment of 50 kg/ha zinc sulfate with thousand grain weights of 433.33 grams was placed at ab classes, and the treatment of control($Zn_0$) with thousand grain weights of 423.33 grams was at b class (table 3).

**Table 4.** Mean scores for interaction effect of different levels of ferrous sulfate and zinc sulfate on yield and yield components of bean.

| Treatment | Biological yield (gr/m²) | Plant height (cm) | Stem diameter (mm) | grain yield (gr/m²) | Weight of one Thousand seeds (Gr) |
|---|---|---|---|---|---|
| Fe0Zn0 | 896[b] | 64.67[de] | 4.83[b] | 461.33[c] | 406.67[cd] |
| Fe0Zn50 | 876.67[b] | 90[a] | 5.67[b] | 525[ab] | 460[a] |
| Fe50Zn0 | 1230.33[a] | 75.33[bc] | 5[b] | 540[ab] | 443.33[ab] |
| Fe50Zn0 | 847[b] | 65.67[de] | 6.67[a] | 561[a] | 426.67[bc] |
| Fe50Zn50 | 920.67[b] | 65.67[de] | 5.67[b] | 487.33[cb] | 436.67[b] |
| Fe50Zn100 | 844.33[b] | 74[cd] | 5.5[b] | 487.33[cb] | 446.67[ab] |
| Fe100Zn0 | 603[c] | 84.33[ab] | 5[b] | 392[d] | 436.67[b] |
| Fe100Zn50 | 955[b] | 69.33[cd] | 5[b] | 430[cd] | 403.33[d] |
| Fe100Zn100 | 821.33[bc] | 59.33[e] | 5.5[b] | 440.67[cd] | 436.67[b] |

Mean scores of each column with at least one shared letter are not significantly different.

The result of comparison between the means indicated interaction effect of ferrous sulfate and zinc sulfate revealed that a significant difference existed between treatments with regard to thousand grain weights. The treatment of $Fe_0$ along with the use of 50 kg/ ha of zinc sulfate ($Fe_0Zn_{50}$) with thousand grain weights of 460 grams was higher than the other treatments and occupied place a. (table 4).

*Economical yield*

Based on the results variance analysis of ferrous sulfate and interaction with zinc sulfate had significant effect on Economical yield at 5%, however zinc sulfatte had no significant effect on Economical yield.

Results from comparing the mean of data showed that effects of different levels of ferrous sulfate on economical yield were significantly. The treatment of not using ferrous sulfate and the treatment of using 50 kg/ha of ferrous sulfate with the yield means of 508.78 and 511.89 gr/$m^2$ respectively, were higher than the yield mean of 100 kg/ha of iron sulfate equaling to 420.89 gr/$m^2$. The treatments were placed at classes A and B respectively.

The results of comparing mean showed that different levels of zinc sulfate did not affect on economic yield significantly. Seed yield was estimated 471.44, 480.78, and 489.33 gr/$m^2$ for the treatments of 0, 50 and 100 kg/ha of zinc sulfate respectively, and placed in class A (table 3).

Based on the results, ferrous sulfate and zinc sulfate demonstrated that there exists a significant difference between treatments in terms of seed yield. The treatment ($Fe_{50}Zn_0$) with yield of 561 Gr/$m^2$ proved higher than other treatments and occupied place A. (table 4).

## Conclusion

Result showed the interaction effect of zinc sulfate and ferrous sulfate on biological yield and stem diameter were significant at 5% level, also observed interaction of zinc sulfate and ferrous sulfate on plant height, economic yield and weight of thousand grain weights were significant at 1% level. Therefore, this study proved to be consistent with findings of Azizi *et al* (2010), Welch *et al* (1991), hemmati (2004), Karimzadeh Aghdam (2007), Kulig (1996) and Malakouti (1999) and revealed that bean is positively reactive to the application of ferrous and zinc. Base on the finding the maximum yield achieved to the treatment ($zn_0fe_{50}$) that showed 38% increase in comparison to control treatment, and recommended in the climate similar to that of yasuj for planting *phaseolus vulgaris*.

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