Effects of Zn, Fe and Mn on soybean production

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ABSTRACT

An experiment was carried out in a factorial based on randomized complete block design with three replications at research farm, Islamic Azad University of Kermanshah Branch at 2010. The aim of this research was to determine the effects of Zn, Fe, and Mn application on soybean production. Treatments includes: three level of Zn (0, 20, 40 kg ha⁻¹), Fe (0, 25, 50 kg Feha⁻¹), and Mn(0, 20, 40 kg Mnha⁻¹), of source ZnSO₄, FeSO₄ and MnSO₄. The end of growth stage, the seed yield and yield components were determined. Analysis of variance was showed that number of pod per sub stem and plant, number of seed per main stem, 100 seed weight per main and sub stem and plant and seed yield at different levels of zinc (P<0.01). Number of sub branch and 100 seed weight in main stem were not affected by iron application. Also, effects of manganese on evaluated traits was significant, likewise, number of sub branch unaffected by Mn application. The highest of number of sub stem, number of pod and seed per sub stem, number of seed per main stem and seed yield were obtained with 20, 25 and 40 kg ha⁻¹ Zn, Fe and Mn, respectively.

Key word: Soybean, yield, yield components, fertilizer, micronutrients.

Introduction

Soybean is an important legume and excellent source of low-cost protein, which biologically and nutritionally resembles animal proteins (Elshiekh et al., 2009). Zinc, iron and manganese are needful elements for normal growth plants, that are needed at little amount (Harrison and Arosio, 1996). Zinc plays an important role in synthesizing proteins and essential catalytic component of over 300 enzymes (Auld, 2001; Welch, 2001; Broadley et al., 2007). If this element is not available sufficiently, plants will suffer from physiological stresses cause by inefficiency of several enzymatic systems and other related metabolic functions (Baybordi, 2006). Soybean needs Fe concentrations in solution higher than 10⁻⁸ M to achieve optimal growth (Lindsay, 1991). Mn has an important role in chlorophyll synthesis, Stabilization of structural protein (Popelkova et al., 2003), and is identified a cofactor for nitrogen catabolism in leaves (Izaguirre-Mayoral and Sinclair, 2005). Various responses were observed in yield and yield components to essential trace elements in crop species and in cultivars within species (Fageria, 2009). Khampariva, (1996) stated that with application of zinc, plant height, number of pods per plant, biological yield, harvest index and grain yield in soybean were increased. Ghasemi-Fasaei et al., 2003 emphasized that application of 2.5 mg Fe kg⁻¹ soil increased top dry weight and Fe concentration in different parts of soybean. Fe deficiency chlorosis is a widespread problem for soybean grown on alkaline, calcareous soils (Lucena and Chaney, 2007). Soybean grain yield and biological yield increase by using 0-20 mg manganese per one kg soil (Singh, 1997). Shahnon et al., 1992) found that application of different potassium levels together with a combination of secondary and micronutrient elements

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including 25 kg magnesium, 33 kg sulfur, 2.5 kg zinc, 2 kg boron, 2 kg manganese, 1 kg copper, 0.2 kg molybdenum and 0.02 kg iron (all per ha) increased soybean yield by affecting yield components. Application of 0, 40, and 80 mg sulfur per one kg soil and 15-20 kg iron per one kg soil increased sub branch, number of pods per plant, length of pods, number of grains per pod, and 100-grain weight (Hemartarajan and Trivedi, 1997). The objective of this study was to determine micronutrients fertilization effects on soybean yield and yield components.

**Materials and Methods**

The present study was conducted at 2010 in the Research field of the Islamic Azad University of the Kermanshah province, Iran (34°23′N, 47°8′E), 1351 meter elevated from sea level. The experimental design was a 3×3×3 factorial experiment based on Randomized Complete Block with three replicate. Three elements zinc, iron, and manganese were used as follows: zinc (0, 20, 40 kg ha⁻¹ from ZnSO₄ source); iron (0, 25, 50 kg ha⁻¹ from FeSO₄ source); and manganese (0, 25, 40 kg ha⁻¹ from MnSO₄ source).

Experiment included 27 treatments placed on 81 plots each of which was 5 m long, including 4 planting rows. Soil samples were collected from experimental area at 0-30 cm depth before basal fertilizer application. The texture of soil based on silty clay with pH 7.6, total organic matter 2.3%, electrical conductivity (ECₑ) 0.61 dsm⁻¹, total nitrogen 0.18%, available phosphorus 9.9 ppm, available potassium 563 ppm, zinc, iron and manganese 0.71, 6.2 and 4.3 mg kg⁻¹, respectively. 27 kg ammonium phosphate (based on 200 kg. ha⁻¹) and 7 kg urea (based on 50 kg. ha⁻¹) fertilizers were evenly spread on the field and mixed with soil with discs. Before planting, seeds were, initially, soaked in 10% sugar solution; then each kg of seeds inoculated with 2 gr of *BradyRhizobium japonicum*.

At the end of growth season, 5 plants were selected from each plot randomly and measured yield components and morphological traits. For measure of total dry weight samples was dried at 70°C and 48 hours. To calculate final yield, 2 middle rows of each plot were completely harvested by taking margins into account. After deducting 13% moisture, grains dry weight was calculated and considered as economic yield. Also, to determine biological yield, whole plant dry weight was considered as biological yield. MSTATC and SPSS software were used to analyze obtained data.

| Source of variation | MS | df | SS | MS | SSM | SVM | SWP | SY | Df | NSM | VSM | WSM | SSM | SVM | WSM | SY | Error
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Coefficient of variation: NSM = 100 × SSM / MS. SSM: Number of seed per plant. SY: Number of seed per hectare. Weight: Number of seed per hectare. Weight: Number of seed per hectare. Weight: Number of seed per hectare. Weight: Number of seed per hectare. Weight: Number of seed per hectare. Weight: Number of seed per hectare. Weight: Number of seed per hectare. Weight: Number of seed per hectare. Weight: Number of seed per hectare. Weight: Number of seed per hectare. Weight: Number of seed per hectare. Weight: Number of seed per hectare. Weight: Number of seed per hectare. Weight: Number of seed per hectare. Weight: Number of seed per hectare. Weight: Number of seed per hectare. Weight: Number of seed per hectare. Weight: Number of seed per hectare. Weight: Number of seed per hectare. Weight: Number of seed per hectare.
Results and Discussion

The results of variance analysis were shown in Table 1. Based on the results obtained there were significant differences in the number of pod per sub stem and plant, number of seed per main stem, 100 seed weight per main stem and sub stem and plant and seed yield at different levels of zinc (P<0.01). Mansur et al., (1995) found that applying zinc caused increases soybean yield by affecting number of grain per plant and seed weight. Also, Khampariva (1996) stated that applying zinc to soybean results in increasing number of pods per plant and grain yield. Number of seed per sub stem affected by zinc application at 0.05 levels. Except of number of sub branch and 100 seed weight in main stem, other evaluated traits affected by iron application. Hemantarajan & Trivedi (1997) emphasized that yield and yield components affected by iron application. Also, Neibur and Fehr(1981) reported that soybean yield increased by iron usage. Effects of manganese on evaluated traits was significant, likewise, number of sub branch unaffected by Mn application. The results of this experiment according to Singh, (1997) and Shalnon et al., (1992). Sanchez-Raya et al., (1974) suggested that Mn uptake and transfer were increased when little amount of Fe is applied, and Roomizadeh and Karimian (1996) reported applied iron can be preventing manganese uptake. While, antagonistic effects of Fe and Mn reported in other researchers (Alam et al., 2001; Grusak et al., 1999).

Results showed that number of sub stem, number of pod per sub stem and plant, number of seed per main stem, 100 seed weight per main stem, sub stem and plant were not affected by interaction effects of zinc and iron. Number of seed per sub stem and seed yield exhibited a highly significant difference at 1% level. Interaction effects of zinc and iron had significant impact on number of pod per main stem and number of seed per plant at 0.05 levels.

Interaction effects of zinc and manganese on number of seed per main stem and sub stem, weight seed per sub stem and seed yield were significant (P<0.01). In addition seed weight per main stem affected by interaction its (P<0.05). Except of Number of seed per main stem and sub stem (significant at 0.01 levels), the other evaluated traits unaffected by interaction iron and manganese and they showed a highly significant difference at 1% level. Number of pod and seed per main stem and seed per sub stem, seed weight per sub stem and plant and seed yield affected by Zn, Fe and Mn interactions (P<0.01). Soybean needs to Zinc, Iron and Manganese emphasized by Lindsay, (1991); Popelkova et al., (2003); Izaquirre-Mayoral and Sinclair, (2005), and Broadley et al., (2007).

Application of 20 kg zinc per ha resulted in the highest number of sub stem, number of pods per plant, number of seed per sub stem and plant and seed weight per plant (Table 2).

Table 2 Mean comparison of studied traits in soybean according to LSD test in %5 level

<table>
<thead>
<tr>
<th>Rate of fertilizer (kg/ha)</th>
<th>NS</th>
<th>NPM</th>
<th>NPS</th>
<th>NPP</th>
<th>NSM</th>
<th>NSS</th>
<th>NSP</th>
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<th>SWS</th>
<th>SWP</th>
<th>SY</th>
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<td>15.31 a</td>
<td>8.14 b</td>
<td>25.12 b</td>
<td>35.17 a</td>
<td>17.57 b</td>
<td>56.67 a</td>
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<td>16.06 b</td>
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<td>18.81 a</td>
<td>58.99 a</td>
<td>17.16 b</td>
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<td>17.50 a</td>
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-Similar letters in each column shows non-significant difference according to LSD test in %5 level -
-NS: Number of sub stem; NPM: Number of pod per main stem; NPS: Number of pod per sub stem; NPP: Number of pod per plant; NSM: Number of seed per main stem; NSS: Number of seed per sub stem; NSP: Number of seed per plant; SWM: 100-seed weight per main stem (gr); SWS: 100-seed weight per sub stem (gr); SWP: 100-seed weight per plant (gr) and SY: seed yield (kg/ha).
The results of interaction effects of zinc, iron and manganese are presented in table 3. These results showed that the highest number of sub stem, number of pod and seed per sub stem, number of seed per main stem and seed yield were obtained with 20, 25 and 40 kg ha⁻¹ Zn, Fe and Mn, respectively. The highest 100 seed weight per plant achieved with 40, 25 and 20 kg ha⁻¹ Zn, Fe and Mn, respectively.

There is a highly significant positive correlation between seed yield and number of pods per main stem (r=0.705*), per sub stem (r=0.527**), and per plant (r=0.636*), and number of seed per main stem (r=0.497*), per sub stem (r=0.511*) and per plant (r=0.725**). There is a significant positive correlation between seed yield and 100-seed weight per main stem (r=0.417), per sub stem (r=0.392) and per plant (r=0.322).

<table>
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<tr>
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| 20                       | 3.40abc | 16.1bcde | 9.3bcdef | 26.9bcdefg | 29.7hi | 19.0efgh | 60.7cdefg |
| 20                       | 3.10abc | 14.3fgh | 9.6bcde | 22.7efghi | 30.2ghi | 10.2kl | 48.6ijkl |
| 20                       | 3.20abc | 18.7a | 9.9bcde | 29.4abcd | 38.8bcde | 27.1b | 70.1a |
| 20                       | 4.00a | 17.0b | 12.7a | 30.73abc | 39.2bc | 33.2a | 70.3a |
| 20                       | 3.10abc | 14.9defgh | 7.1efg | 22.6fghi | 28.6ij | 9.8l | 50.1hijk |
| 20                       | 3.30abc | 16.1bcde | 10.0abcd | 31.4a | 30.7ghi | 18.2fgh | 69.7ab |
| 20                       | 3.50abc | 16.0bcde | 10.0abcd | 31.4a | 31.9fgh | 22.3cd | 66.3abcd |

|                          |    |     |     |     |     |     |     |
| 40                       | 2.70c | 14.6efgh | 11.43ab | 23.7efghi | 31.2ghi | 19.6defg | 45.0ijkl |
| 40                       | 2.90bc | 15.9bcde | 7.5defg | 25.5defgh | 30.2ghi | 20.2cde | 63.0abcde |
| 40                       | 2.90bc | 16.1bcde | 10.0abcd | 26.9bcdefg | 39.6bc | 10.01 | 67.5abc |
| 40                       | 3.00bc | 15.3defgh | 10.0abcd | 26.6cdefg | 39.9abc | 21.4cde | 54.3fghi |
| 40                       | 3.70ab | 16.2bcd | 9.7bcde | 30.5abc | 41.6ab | 16.4ghi | 61.2bcdef |
| 40                       | 3.10abc | 16.2bcd | 10.2abcd | 31.2ab | 40.2abc | 20.7cde | 65.3abcde |
| 40                       | 3.40abc | 14.0ghi | 7.9cdefg | 24.3efghi | 35.2defg | 19.3defg | 43.2klm |
| 40                       | 3.40abc | 16.0bcde | 10.5abc | 26.9bcdef | 30.1ghi | 20.2cde | 65.9abcde |
| 40                       | 2.90bc | 17.1b | 10.5abc | 33.2a | 32.2fghi | 21.1cde | 64.8abcde |

-Similar letters in each column shows non-significant difference according to LSD test in %5 level.
-NS: Number of sub stem; NPM: Number of pod per main stem; NPS: Number of pod per sub stem; NPP: Number of pod per plant; NSM: Number of seed per main stem; NSS: Number of seed per sub stem and NSP: Number of seed per plant.
Table 3. Mean comparison 100-seed weight in main stem, sub stem & plant and Grain yield in soybean according to LSD test in %5 level

<table>
<thead>
<tr>
<th>Rate of fertilizer (kg/ha)</th>
<th>Mean</th>
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<tbody>
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<td>Zn</td>
<td>Fe</td>
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<tr>
<td>40</td>
<td>50</td>
</tr>
</tbody>
</table>

-Similar letters in each column shows non-significant difference according to LSD test in %5 level.
-SWM: 100-seed weight per main stem (gr); SWS: 100-seed weight per sub stem (gr); SWP: 100-seed weight per plant (gr) and SY: seed yield (kg/ha).

Table 4. Pearson correlation coefficients among evaluated traits in soybean

<table>
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<tr>
<th></th>
<th>NS</th>
<th>NPM</th>
<th>NPS</th>
<th>NPP</th>
<th>NSM</th>
<th>NSS</th>
<th>NSP</th>
<th>SWM</th>
<th>SWS</th>
<th>SWP</th>
<th>SY</th>
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<tr>
<td>NPM</td>
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<td>0.576**</td>
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<tr>
<td>NPP</td>
<td>0.205**</td>
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<tr>
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<td>0.518**</td>
<td>0.405*</td>
<td>0.571**</td>
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<td>0.421*</td>
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<tr>
<td>NSP</td>
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<td>0.744**</td>
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<td>0.545**</td>
<td>0.638**</td>
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<tr>
<td>SWM</td>
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<td>0.408*</td>
<td>0.382*</td>
<td>0.372*</td>
<td>-0.109*</td>
<td>-0.039*</td>
<td>0.139*</td>
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<td>SWS</td>
<td>-0.152**</td>
<td>0.428*</td>
<td>0.364*</td>
<td>0.388*</td>
<td>0.204*</td>
<td>-0.382*</td>
<td>0.201*</td>
<td>0.766**</td>
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<tr>
<td>SWP</td>
<td>0.082**</td>
<td>0.371*</td>
<td>0.418*</td>
<td>0.354*</td>
<td>0.138*</td>
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<td>0.200*</td>
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<td>0.821**</td>
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<tr>
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<td>0.705**</td>
<td>0.527**</td>
<td>0.636**</td>
<td>0.497**</td>
<td>0.511**</td>
<td>0.725**</td>
<td>0.417*</td>
<td>0.392*</td>
<td>0.322*</td>
<td>1.00</td>
</tr>
</tbody>
</table>

-ns, * and **: Non significant, significant at 5 and 1% levels of probability, respectively
-NS: Number of sub stem; NPM: Number of pod per main stem; NPS: Number of pod per sub stem; NPP: Number of pod per plant; NSM: Number of seed per main stem; NSS: Number of seed per sub stem; NSP: Number of seed per plant; SWM: 100-seed weight per main stem (gr); SWS: 100-seed weight per sub stem (gr); SWP: 100-seed weight per plant (gr) and SY: seed yield (kg/ha).
Acknowledgments

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References